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The Development of Design and Technology from a Problem-solving Perspective - Apropos Eleven to Fourteen Year-old Pupils within the English Education System

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Abstract

The purpose of this study is to establish the efficacy of problem solving within design and technology as experienced by pupils, teachers and 'experts' in England. Participants in the study included a representative sample of pupils and teachers involved in teaching and learning of this subject within key stage 3 (pupils aged eleven to fourteen). Further participants comprised two complimentary groups of 'experts', including researchers, teacher trainers, advisers and inspectors.

In addition to a review of literature, focus group interviews took place with a range of design and technology / technology departments and a sample of their respective pupils. Two further group interviews occurred with groups of design and technology education 'experts'. Responses to questions were analysed using a constant comparative method of handling qualitative data associated with the concept of grounded theory.

Findings of this study were as follows:

In spite of imperatives for problem solving to be paramount throughout the development of design and technology - culminating in various national curriculum versions during the 1990s - teachers found problem solving, within their experience, ill-defined and confusing. While there was a consensus that problem solving was important, teachers felt dissatisfied about its effectiveness. Pupils confirmed the aspects of uncertainty raised

by their teachers. Generally, teachers recognised a need, and, expressed a desire, for more in-service training and support regarding problem solving.

In addition to 'confirming' concerns about problem solving, expressed by their teachers, pupils wanted more and better problem solving within design and technology. They also expressed a desire for better links to be made to other dimensions of design and technology.

Data emanating from groups of 'experts' confirmed issues raised by teachers and pupils.

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Chapter 1 Introduction

Introduction

> Much of education is intended to make people better problem solvers.
>
> (Andre, 1989: 60)

As teachers of design and technology we operate within a context often described as an ever-changing technological society. It is vital that they continue to reflect on the purpose of teaching and learning in order that those engaged in learning develop as independent autonomous problem solvers, not dependent on a fixed body of knowledge and skills. Allied to general educational change, the rate of change and advancement of technology means that teachers operate within a curriculum area of increasing importance and influence on the economy and society. Therefore, a balance must be struck between teachers' skills in handling new technologies and educational change in terms of goals and purpose, as:

> A growing number of studies suggest that even those with sophisticated formal knowledge of a subject can be bad at using it in unfamiliar surroundings or to solve novel, complex problems. This inability to transfer knowledge from one domain to another points to a lack of real understanding, a crucial failure in a world where problem solving and transferable skills are at a premium.
>
> (Bentley, 1998: 9)

The 1990s represented a period of educational change with a national curriculum conceived to encompass a subject entitled technology (design and technology) with the intention of, '...developing pupils' competence to tackle a wide variety of problems, drawing on a broad base of knowledge and skills' (Department of Education & Science and the Welsh Office, 1998: page 1 of the Secretary of State's 'forwarding letter'). However, it was acknowledged that by the latter stage of this decade, that education was still dominated by *what* students know, rather than *how* they use knowledge (Seltzer & Bentley, 1999).

Statement of the Problem

Problem solving activities have been central to the development of design and technology (D&T) in schools and yet there is a lack of sufficient comprehension and understanding of, and insight into, the processes involved.

While national curriculum design and technology approaches have continued to advocate a humanistic methodology based on the importance of problem solving, the limited success has been due partly to a mismatch between teachers' existing insight, familiarity and 'expertise' and the demands of teaching (and learning) based on such methods. There is clearly an absence of adequate consideration given to appropriate ways of teaching design and technology to (mixed ability) groups based on problem solving. This is compounded by the need and desire to manufacture 'solutions/design ideas'.

It is often 'supposed', 'assumed' or 'presumed' that teachers have an existing and substantial understanding of problem solving operational processes as part of a hierarchical conceptual framework. Observations point towards a lack of a clear understanding about expectations of pupils able to work independently on problems, and the ways in which such problems can legitimately be framed in order that pupils of a corresponding ability are able to respond. There is a need to clarify the meanings attributed to the terms 'problem' and 'problem solving' (as used within this context) which are often used by others, with differing connotations. This point also links to the perceptions by those other than teachers, such as 'politicians', 'promoters', 'evaluators' and 'pressure groups' – since there should be a clear understanding of the intellectual demand made on pupils when working on independent open-ended design-based problem solving involving the manufacture of products. A contemporary claim made for the involvement of pupils in such activities 'boasts' that:

> Design and technology is uniquely placed to develop all these skills. It enables pupils to apply their knowledge, skills and understanding creatively in practical coursework activities. Design and technology also provides opportunities for pupils to improve their own learning and performance through tasks that support pupils' own approaches, following plans to meet negotiated targets, and through evaluating the whole designing and making process.
>
> It is in the area of problem solving, however, where the potential to develop creativity is strongest, through dealing with conflicting problems when making products and through considering alternatives when investigating ways forward and evaluating those products.
>
> The creative problem-solver needs the ability to formulate new problems when designing, to transfer general knowledge and understanding to a relevant designing and making context and to focus attention on a goal. (...)
>
> ...Setting a problem-solving exercise within a practical design and make process that pupils can trust forms boundaries against which the creative mind can push. (...)

> ...As the national curriculum for design and technology makes clear, pupils "learn to think and intervene creatively to improve the quality of life. The subject calls for pupils to become autonomous and creative problem-solvers as individuals and members of a team."
>
> (Williams, 2000: 5)

Each of these claims made in the context of the 1999 national curriculum review embeds a number of untested assumptions.

Purpose of the Study

Personal interest, as a practitioner and researcher, has developed in determining the 'nature' and 'effectiveness' of problem stating and problem solving, and the relationships between teachers and pupils engaged in these processes. Part of this interest has been associated with the notion of progression and operational levels linked to pupils working independently on open-ended design-based problem solving.

Key stage 3[1] was chosen for this study as it involves pupils operating within a phase of schooling with a greater focus on 'specific' design and technology activities, without the direct influence of formal examinations, apart from SATs[2]. Teachers engaged in such activity with the pupils should in principal have relatively more freedom and control over the types of activities and forms of teaching and learning within this phase.

[1] The National Curriculum within England and Wales is split into four, representing the four 'key stages' for compulsory schooling. Key stage 1 is for pupils between five and seven, key stage 2 between eight and eleven, key stage 3 between eleven and fourteen, and key stage 4 between fourteen and sixteen.
[2] Standard Attainment Tasks are part of the national curriculum assessment procedures. Originally conceived as normal assignments with built in assessment. Since 1990 they have been renamed Standard Tests or Standard Tasks (STs). But they are still widely referred to as SATs.

The initial stage of the research involved focus group interviews with 'design and technology departments' and groups of corresponding key stage 3 pupils (two year 7 [Y7], two year eight [Y8] and two year nine [Y9]) in twelve contrasting schools, with additional interviews with two groups of 'experts' within the field of design and technology education in schools. This enabled the construction of 'models of insight' into the research focus as well as recognition of emergent issues.

Research Questions

To investigate the nature and perceived effectiveness of problem solving in key stage 3 design and technology, the following questions were addressed.

1 How has problem solving been considered within the development of:

  a) general education;
  b) precursors to design and technology;
  c) pre-national curriculum design and technology;
  d) national curriculum design and technology;
  e) future educational and societal needs and requirements?

2 What is the perception of problem solving from the viewpoint of:

  a) a sample of teachers involved in key stage 3 teaching;
  b) a corresponding sample of key stage 3 pupils;
  c) a corresponding sample of 'experts' within the field of design and technology (advisers and inspectors associated with the sample schools);

d) a further group of 'experts' of national (and international) standing?

Significance of the Study

Problem solving has been regarded as essential within education, work and society (McCade, 1990; Simon, 1980; Tuma & Reif, 1980; Cyert, 1980; Johnson, 1994a, 1997). The 1990s represented a period of time when accelerated pace of change demanded a reassessment of the needs of individuals within education. There was a perception that design and technology could and ought to form a catalyst for such development (Millray, 1988; Johnson, 1997). Initial consideration of a national curriculum for the 1990s placed great emphasis on an approach to education encompassing problem solving through the highly regarded 'subject' of technology (design and technology) (Department of Education & Science and The Welsh Office, 1988, 1989; Murphy, Hennessy, McCormick & Davidson, 1995). However, such curriculum change of a 'new order' demands a corresponding emphasis on pedagogical consideration and consequence (Johnson, 1994a, 1997; Jones, 1997; McCade, 1990). Future needs are based on what individuals can do rather than what they know, and it is crucial that those engaged in learning and teaching develop corresponding strategies (Eggleston, 1976; Johnson, 1994a, 1997). However, it is evident that many assumptions were and are made still about problem solving ability emerging 'through osmosis' and simply placing individuals and groups in problem solving situations, as opposed to necessary consideration of effectiveness in learning and teaching with a focus on 'teaching problem solving' (Norman, 1980; Andre, 1989; DeLuca, 1991; McCormick, Hennessy & Murphy, 1993; Johnson, 1994a, 1997). Indeed, terms such as 'facilitators' and 'enablers' are used in response to satisfying such needs and requirements, but is there arguably a need to alter approaches to curriculum content and approaches to teaching to deliberately enable problem solving capability to develop (Andre, 1989; McCade, 1990; DeLuca, 1991; Johnson, 1994a, 1997).

This study ultimately provides practitioners within design and technology with information related to issues associated with the implementation of national curriculum design and technology through the 1990s, and acts as a backdrop to consideration of the nature of problem solving and the effectiveness of individuals solving problems. The emphasis of the study is on pedagogical issues, and as such, attempts to encourage practitioners to strike a necessary balance between consideration of contemporary subject knowledge and appropriateness of approaches to teaching.

Definitions and 'Relationships'

As indicated above, one of the major issues associated with the focus of research is '<u>what do we mean by problem solving within design and technology?</u>'.

In a more general sense, beyond the realms of design and technology, we have the following definitions:

> One simple yet meaningful definition describes a problem as a need which must be met (Ritz, et al. 1986a).
>
> (McCade, 1990: 28)

> Most discussions of problem solving are usually consistent with this definition: *A problem is a situation in which the individual wants to do something but does not know the course of action needed to get what he or she wants* (Newell & Simon, 1972).
>
> (Andre, 1989: 61)

> Problem solving consists of the mental and behavioural activities that are involved in dealing with problems. Problem solving may involve thinking (cognitive) components, emotional or motivational components, and behavioural components.
>
> (ibid: 61)

It was acknowledged that:

> While problem solving is central to education, the study of problem solving has historically received only sporadic attention from educators and educational psychologists. An explicit theory of problem solving has not been available and educators interested in promoting problem solving have primarily been engaged in guesswork when designing programmes.
>
> (ibid: 60)

Within the context of contemporary writing about problem solving in design and technology, there is also acknowledgement of little reference to research; however, links to research can be found within the areas of mathematics and science (McCormick, Hennessy & Murphy, 1993), and so we return to the need for a consideration of, *'but what sort of problem solving are we talking about in design and technology?'*. It has, in fact, been recognised for some time that there is a distinction to be considered within design and technology (craft design and technology [CDT]) between problem solving based on *algorithmic strategy* and that based on *heuristic strategy* (Down, 1983).

Additionally, 'what is the relationship between designing (and the design process) and problem solving?'

From an American perspective, we see that problem solving is much more than just design (McCade, 1990), where it is proposed that design (and troubleshooting) are subcategories of problem solving (ibid), even though, 'some use the terms "problem solving" and "design" interchangeably' (ibid: 29). In contrast, the general assumption within design and technology teachers and educators in the United Kingdom is that problem solving is a subcategory of designing (and making) (Research Interview Data).

The development of design and technology has included emerging influence of design and the concept of design education. Typically, designing and problem solving featured within deliberations on the nature of design education.

> At the heart of the matter is the design process. This is the process of problem solving which begins with a detailed preliminary identification of a problem and a diagnosis of the needs that have to be met by a solution, and goes through a series of stages in which various solutions are conceived, explored and evaluated until an optimum answer is found that appears to satisfy the necessary criteria as fully as possible within the limits and opportunities available.
>
> (Eggleston, 1976: 17)

In spite of reservations expressed over the use of simplified 'stage models' in terms of simulation of 'real problems' (Johnson, 1994a, 1994b) their use is prevalent throughout design and technology (Jones, 1997; Chidgey, 1994; HMI, 1992, cited in McCormick, Hennessy & Murphy, 1993). 'The models employed to introduce the meaning of 'designing' and 'technology' to schools had superficial similarities and with enough simplification became 'the design process', to which reference is now commonly made' (Roberts & Norman, 1999: 124). Despite the importance of problem-solving competencies, an emphasis, or dependence, on such stage models has remained to the fore throughout the period of action research (research interview data). As such, linear models of designing provide a contextual context to the development of the subject as well as subsequent discussion.

Furthermore, '<u>what is the relationship between problem solving and creativity?</u>'.

Historical analysis highlights a strong relationship between the 'design process' and various models of creativity. This indicates that the development of the teaching of design and technology might benefit from a stronger consideration, and application of, pedagogical issues associated with creativity in education.

Which leads us to consider '<u>can teachers actually teach problem solving?</u>'

There is clearly an existing consensus. For example:

> The important point about problem solving is *not* that some people are better at it than others. Instead, the important point is that *problem solving can be learned.* It frequently isn't learned because it isn't taught. In school, for example, we are generally taught *what* to think rather than *how* to think. This is not due to some great conspiracy to "hide the secrets of thinking and problem solving from the general public". Instead, many teachers are simply unaware of the basic processes of problem solving *even though they may unconsciously use these processes themselves.* It therefore never occurs to them to make these processes explicit and to teach them in school.
>
> (Bransford & Stein, 1984: 3)

Assumptions and Limitations of the Study

The aim of the study was to gain an understanding of problem solving within design and technology and provide an underpinning for consideration of its effectiveness in terms of desirable outcomes. Those selected for involvement in the collection of data, based on focus group interviews, represented a cross-section of participants, and as such the opinions expressed by those involved in the teaching and learning of design and technology was reflective of developments throughout the 1990s.

In the study, emphasis is placed on an extensive review of literature, in order to compare the relative merits of 'problem solving' arguments within education and more specifically within design and technology and its antecedents.

Chapter 2 Literature Review

Historical Perspective

Research into the background of problem solving within school-based design and technology shows that a number of influential figures predominate. Some of these are considered within the 'defence' of the practical experiential nature of this subject as opposed to others who are associated with the concept of problem solving within the overall curriculum (which then can be applied within design and technology).

Dodd (1978) in his research into the development of the school subject of design and technology acknowledged, in particular, the influences of Comenius, Rousseau, Pestalozzi and Froebel. The pedagogy of Commenius was based on methods which fostered 'ownership of knowledge' and 'learning by experience' which, in conjunction with Bacon and Locke, influenced an apparent change in attitude towards learning and teaching during the seventeenth century in England. Rousseau's pedagogical stance was designated by the term 'Naturalism' and was associated with the emphasis placed on the natural development of the child. His influential book, 'Emile' (originally published in 1762), promoted education as being active, natural and useful, and gave rise subsequently to the 'Heuristic method'.

> Put the problems before him and let him solve them himself. Let him know nothing because you have told him, but because he has learnt it himself. Let him not be taught science, let him discover it.
>
> (Rousseau, 1974: 131)

This work had a considerable influence on so-called 'progressive education'. Rousseau's fictional character 'Emile' was also to learn a practical task and can therefore be seen as having resonance in an area of the curriculum such as design and technology (and its previous incarnations), particularly during the more 'liberal' phases of its development. Rousseau's influence was considerable, even amongst those who disagreed with many of his ideas and principles. In addition to others, both Pestalozzi and Froebel took many of their ideas from those presented in 'Emile'. Pestalozzi's experimental approach based considerable emphasis on learning through activity in preparation for 'fitness for life' allied with 'independent action'.

Herbart, a reader of Rousseau and a disciple of Pestalozzi, developed the principle of 'correlation' associated with formal steps of instruction, which bear certain similarities to stages often adopted within 'problem-solving approaches' in design and technology. Herbartian psychology was based on the notion that the curriculum should actively promote the 'correlation' of issues covered in different lessons and at different times since similar ideas blend and reinforce each other. (Dissimilar ideas have a negative effect on absorption and reinforcement of new ideas.) Herbart coined the term 'apperceptive mass' to describe such a situation where the mind is able to operate in such a productive way. Therefore the teacher needed to consider aspects of progression to ensure assimilation of new ideas to old. Herbart's teaching method was originally based on four steps, but was extended to five by his followers (referred to as the 'five normal steps' of problem solving by Shepard (1990)):

- Step One - 'Preparation'. This involves a sense of revision in order that 'old' knowledge, deemed to be relevant to the new knowledge, is consciously considered and therefore 'brought back' into the minds of the learners.

- Step Two - 'Presentation'. This involves the teacher focusing on new facts and procedures in conjunction with any relevant demonstrations.

- Step Three - 'Association'. This involves the teacher assisting the learners with the analysis of the new aspects and comparing and contrasting it with the old, thereby ensuring 'apperception' is achieved. This is considered to be a crucial stage in the whole process.

- Step Four - 'Systemisation' (also known as 'generalisation'). This involves recapitulating or reviewing that which has been learnt, with an emphasis on that which has been learnt within a broader context and wider significance.

- Step Five - 'Application'. This involves the practise of the new skill and the use of the new knowledge in other contexts, and importantly the use of such new aspects to solve other problems.

It could be argued therefore that such a model was based very much on providing a structured framework to enable 'self-activity', as a result of the concept of 'apperception'. Herbart therefore did not follow Rousseau's principle based on 'naturalism', but did believe in the importance of the relationship between interest and self-activity with an emphasis placed on the teacher as a guide.

Froebel is also acknowledged as a seminal influence on the earlier stages of learning and is acknowledged for the development of creative self-expression and the establishment of 'kindergartens'. His approach was developed in response to misgivings over methods of teaching and learning which he considered based primarily on the inculcation of a narrow range of skills and knowledge established and valued by past generations. The role of teachers varied considerably from Pestalozzi's approach in that they were not to impose their methods and materials within the context of learning. Instead, 'structures' should be available for the learners to use, under guidance.

More Recent Influences

Dewey's considerable influence on education has also been acknowledged by writers such as Hirst (1974), Kelly (1977), Dodd (1978), Peters (1981) and White (1982). Dewey placed particular emphasis on the process of education and development of thinking within a context of problem solving, often in groups. Again, there was an acknowledgement of the importance of preparation for life in the future as opposed to a curriculum based on imparting existing knowledge. Teachers should not only help children to cope with the contemporary context, but enable them to become competent at coping with new experiences and the as yet unknown. Dewey wrote about the curriculum within the context of American elementary schools and stressed the importance of practical activities such as sewing, cooking, weaving, carpentry and metalwork, and was convinced that children are interested in such things which embody motor activities closely connected with mental development as a whole.

> For Dewey, impressed by the evolution of mind in nature, it became above all practical, taking the form of adapting new means to ends when usual means were unavailable. Intelligence was reconceptualised as problem solving.
>
> (White, 1982: 14)

He believed passionately that the curriculum should be socially relevant and that such an approach should contribute to making children active members of a 'democratic society'. Arguably, 'Dewey's ideal of the technological problem-solving man' (Peters, 1981:84) greatly influenced those who advocated a learner-focused problem-based curriculum which would prepare future adults for an ever-changing technological society. However, Peters (1981) expressed some concern over such a philosophy in terms of the over-emphasis placed on problem solving. The work of Dewey was associated with notions of 'child-centredness' and, despite his perceived alignment to so-called 'progressive education', he was actually critical of models of education where teachers seemed to be afraid even to make suggestions about ways in which groups of children could utilise materials provided (Dewey, 1963 - originally published in 1938). Here we begin to gain an insight into the relationship between the development of facets of education (such as practical education) and the tensions between advocates of 'progressive' and 'traditional' models of curriculum and implementation. A theme which will be examined in greater detail at a later stage.

Dewey's 'problem method' of learning recognises that thinking develops to a much greater level when the child is confronted with a problem where they have to consider choices which personally affect themselves or others, particularly when working together to solve a common problem. Therefore, in tackling problems, thinking and 'inductive reasoning' develops within a real context and each suggested 'solution' along the way is judged in terms of the larger problem (Dewey, 1991 - originally published in 1910). In 'How We Think' (1991) Dewey expands on his theory and presents five distinctive stages associated with problem solving:

- Stage One: Consciousness of a problem or obstacle.

- Stage Two: The 'mental survey' - analysis of the situation and consideration of main factor(s).

- Stage Three: The listing of possible solutions.

- Stage Four: Consideration of the implications of each possible solution and consequent comparisons leading to judgements of suitability.

- Stage Five: Application of the decision leading to conclusion in terms of its success or failure.

The role of the teacher was considered as being that of a 'facilitator' as opposed to 'instructor', and there was an emphasis on the pupil's own creations and discoveries. Consequently the term 'learning by discovery' was adopted and later utilised in the promotion of mixed-ability teaching, with pupils being able to work at their own pace with a greater sense of 'ownership'. Links were drawn between 'learning by discovery' and 'problem solving' by people such as Dearden in the 1960s. Such an approach was promoted on the basis of the quality of knowledge gained while working within general heuristic principles, as well as notions of 'learning how to learn' and being able to 'transfer' such experiences to new contexts and indeed new problems. However, it is important to note that such an approach to teaching and learning was presented within a cautious framework whereby the teacher had a definite role in determining and planning for purposeful activity: 'The teacher does not 'provide experiences' but *guides* experience...' (Dearden, 1967: 151). It is important, therefore, that teachers engaged in this approach are adept at teaching within an organised framework in terms of 'desired direction', framing of problems, progression and sequencing, while at the same time enabling genuine discoveries to be made. It should also be noted that such a 'discovery method' was being proposed within a variable approach to teaching - not as a doctrine based exclusively on one approach. As 'intelligent teachers' (Dearden, 1967) they should choose the appropriateness of teaching methodologies such as 'instruction' in conjunction with a range of approaches. Interestingly Dearden ends his advocation of such an approach with a note of caution: 'The possible superiority of this (...) conception of learning by discovery over learning from intelligent instruction would need to be shown empirically, though one can see that on some occasions at least it might well be superior on account of its greater adaptation to individual differences and greater scope for intelligence' (Dearden, 1967: 154).

According to Shepard (1990) Dewey made a number of important observations associated with the classroom context in terms of the experiences of the pupil:

- The problem must be a real one, that is, real to the pupil, and be a stimulus to further thought.
- The pupil must have the necessary information, and make the observations required to deal with the problem.

- The pupil needs to be placed in the position of the researcher, developing his or her ideas and seeking an individual solution.
- The pupil must be allowed to try out and test the validity of his or her own conclusions.

(Shepard, 1990: 23)

Arguably, such aspects need to be to the fore when considering the appropriateness of 'projects' within the context of problem solving approaches in design and technology. If pupils are, for example, simply not interested in or fail to see the relevance of the problem 'set', then the potential of the work in terms of pupil progress is minimised. Furthermore, teachers may consider that, as a consequence of ensuing difficulties in terms of pupil motivation, behaviour and achievement, that such an approach is inappropriate or simply does not work, and they may indeed revert back to more 'traditional' modes of teaching. Down (1983) questioned the claim of supposed motivational superiority through the adoption of problem solving in craft design and technology (CDT) and reminded us that the artificiality of imposed school-based problems contrasts with Dewey's support for motivation through ownership of problems and the associated processes. In addition to, and associated with this, he reminds us of Ausubel's comment that 'problem solving can be just as deadening, just as formalistic, just as mechanical, just as rote as the worst form of verbal exposition' (Ausubel, 1978, cited in Down, 1983) and consequently recognises the importance of teachers who can be of a stimulating disposition and make a weak method come alive (Down, 1983). Conversely, we could add the scenario of 'weak' teachers stultifying strong methods, which can be seen to link to Down's concluding remarks where he considers that, 'It seems to me that in the end my problem and the problem I find in this area is a lack of clarity about aims' (ibid: 43).

The study of animal behaviour became influential during the twentieth century. The 'behaviourist' theory of thinking dominated American psychology between the 1920s and 1950s. Thorndike's study of the behaviour of cats led to his 'trial-and-error' learning model within the framework of 'stimulus-response' theory. Problem solving is put forward as a trial-and-error application of common tendencies or habits, where the problem solver, through a trial-and-error process, tries different responses until an effective solution is realised. Criticism of such behavioural views included the lack of room for thought and planning in problem solving and implicit randomness of such human activity (Andre, 1989), and ignores the cognitive processes involved (Johnson, 1994). In contrast, German Gestalt psychologists developed, between the 1920s and 1940s, an alternative 'holistic' approach to psychology emphasising the role of mental structure and organisation in perception and thinking. Gestalt psychology proposes that problem solving involves a search for relationships between, and reorganisation of, various aspects of the problem situation to discover how all parts in a problem fit together to reach a solution. Kohler's study of chimpanzee behaviour led to his consideration of the sudden restructuring of a problem in terms of 'insight'. However, it has subsequently been shown that apparent sudden 'insight' is actually a mental continuation of the search for a/the solution which can be explained in terms of cognitive processes involving the reorganisation of knowledge structure (ibid). From the early 1960s, interest transferred from behavioural approaches to those which encompassed cognitive information-processing, based on the computer as a metaphor for the brain (Newell & Simon, 1972). This model consists of the three structures of: sensory register; short-term memory, and; long-term memory, performing the functions of: inputting; coding; storing, and; transforming within the mind. The focus of this work has been on the identification and description of how problem solving occurs as opposed to the ways in which individuals ‘learn’ to become problem solvers (Andre, 1989). However, ‘By viewing problem solving as an active process of information processing, educators can develop instruction that emphasises the cognitive skills needed for problem solving’ (Johnson, 1994: 159).

Developments Associated with Creativity

At this stage one needs to be conscious of the use of such influences and models in differing viewpoints about the relationship between ‘problem solving’, the development of design and technology, and ‘creativity’. In addition to, and developing from, Herbart’s five normal steps of creativity, further stage models have been utilised within the context of creativity within education and industry. Notions and theories of ‘creativity’ have subsequently developed which have often been represented in linear formats. However, such stage models are based on introspections by the likes of Wallas and others on what they think people are doing when problem solving, as opposed to psychological experimentation (Mayer, 1992). It has been suggested, ‘Creativity has come to be regarded as nothing more than a special type of problem solving, characterised by novelty, persistence and the extreme difficulty of formulating the problem’ (Bell, 1982:109), incorporating the five stages of: obtaining the facts; identifying the problem, formulating alternative solutions; selecting the best solutions; and, putting the selected solution into practice (ibid).

From the perspective of education and creativity, researchers such as Guilford (1950, 1959, 1967), Getzels and Jackson (1970) and Torrance (1970) indicated how conscious educational strategies could enhance the quality of creativity in individuals. Guilford’s claim that, 'Like most behaviour, creative activity probably represents to some extent many learned skills' (Guilford, 1952, cited in Parnes, 1970: 342) influenced further research and by the end of the 1950s a range of research projects had identified positive links between deliberate teaching procedures and the efficacy of creativity (Taylor, 1959, cited in Parnes, 1970).

One important aspect associated with such interest and development was the concept of different types of thinking for different purposes. In clarifying the nature of creativity Guilford distinguished between abilities for divergent thinking and for convergent thinking (sometimes referred to as critical thinking). Such work associated with creativity emphasised the importance of divergent thinking and was recognised as necessitating a change from the curriculum model and teaching styles based on known fixed answers. Divergent thinking was described as 'thinking that moves outward from a problem in many possible directions, such as required in "List all the uses for a brick"' (Mayer, 1992: 361) and was considered to involve 'originality, fluency of ideas, flexibility, sensitivity to defects and missing elements and the ability to elaborate and redefine' and necessitated 'new ideas, an original or unconventional response, and breaking away from the beaten path' (Razik, 1970: 159).

In association with the requirements of divergent thinking there was a consideration of how one might measure such a process. According to Davis, 1989:

> Solutions to divergent thinking problems are most often scored for two factors:
>
> *Fluency* - the number of solutions that fit the requirements of the problem, and

Originality - the number of unusual or unique solutions, that is, solutions generated by very few or no other people.

(Cited in Mayer, 1992: 362)

Aside from issues associated with manufacturing solutions to problems, we can see the complexity of creative practical problem solving emerging in terms of skills required in both divergent thinking and convergent (critical) thinking.

It was recognised that there was a problem associated with pedagogical issues and a need to 're-educate' and retrain teachers in order that they might be able to teach effectively within a curriculum model based on a greater emphasis on creativity (Razik, 1970). And so we see that although the importance of creativity within education was acknowledged it was also recognised that there was a need for further work associated with the 'teaching of creativity' within schools in addition to the need for teachers themselves to have a greater understanding of and sympathy for creativity. Perhaps at this stage we see the beginning of assumptions made in terms of simply presenting pupils with 'problems to solve' without sufficient regard for the demands placed on teachers and pupils. There is a general sense that there is a need, or indeed a requirement, for creative teachers to teach in a creative manner for creative learning to take place (ibid). More specifically, creative divergent thinking can be considered a cognitive activity that results in one or more novel solutions to a problem, with a consequential need for creativity training involving teaching pupils how to generate new ideas in response to a problem; and divergent (critical) thinking can be considered as a cognitive activity that results in the selection of an appropriate solution, with a consequential need for training in how to evaluate and test ideas regarding a problem (Mayer, 1992). In terms of any hierarchical structure associated with intellectual development or cognition, such abilities and skills can be seen to be of a demanding nature, particularly when included, amongst other requirements, within one overall process.

The world of education was also influenced through the growth of creativity training in American-based industry during the 1930s and 1940s. This was initially targeted at specific groups within industry such as: engineers, managers and product designers. Crawford's creativity training course of 1931 is often acknowledged as being the first. A major feature of this course is the concept of 'attribute listing' which involves listing the critical attributes of a product and then listing possible modifications for each attribute or suggesting the transfer of attributes from one object to another. Osborn developed the popularised technique of 'brainstorming' during the 1940s, set within the context of generating as many unusual ideas as possible with a 'denial' of criticism of such ideas.

Gordon (1961) developed the use of 'Synectics' incorporating the use of analogies within group-based problem-solving. The word 'Synectics', from its Greek derivation, means the joining together of different and apparently irrelevant elements, and Synectics theory applies to the integration of diverse individuals into a problem-stating problem-solving group. Gordon's purpose in developing such a theory was to increase the probability of success in problem-stating, problem-solving situations. Gordon (1961) considered Synectics to be an operational theory for the conscious use of the preconscious psychological mechanisms present in our creative capacity. To assist in the solving of problems the Synectic process involves:

1. *Making the strange familiar*, meaning the familiarisation of aspects of the problem and the forming of concrete assumptions as well as establishing ramifications and fundamentals, and;

2. *Making the familiar strange*, meaning the distortion, inversion, or transposition of everyday ways of looking and responding which render the world a secure and familiar place.

Much of Gordon's book is concerned with the development of an outline of the Synectics process as a basis for putting into practice the various phases of Synectics theory:

Phase 1: Problem as given - Assumption that the problem is given at this stage, as opposed to being sought.
Phase 2: Making the strange familiar - Familiarisation with new elements concerning the problem, in terms of those elements being new to those involved.
Phase 3: Problem as understood - Analysis of various 'atomistic bits' of information about the problem.
Phase 4: Operational mechanisms - Analogies and metaphors are considered and developed related to the problem, 'pushing' and 'pulling the problem beyond its 'rigid' form.
Phase 5: The familiar made strange - As a consequence of the 'mechanisms' in stage 4, the apparently unfamiliar becomes familiar in terms of possible solutions.
Phase 6: Psychological states - Attitude of mind is altered in terms of 'involvement', 'detachment', 'deferment', 'speculation' and 'commonplace-ness', resulting in the

achievement of a more contusive climate for creative activity - the central premise of Synectics theory.

Phase 7: States integrated with problem - The most pertinent analogy/analogies is/are considered in terms of the problem as understood.

Phase 8: Viewpoint - Consideration of the 'technical' insights resultant from the earlier 'mechanisms' linked to consequential development of existent ideas, and/or the development of new viewpoints.

Phase 9: Solution or research project - Viewpoint becomes practicable in terms of testing of the underlying principle, or alternatively the viewpoint becomes the focus for further research.

This format looks similar to various incarnations of 'design processes' incorporated and used by teachers of craft design and technology (CDT) and design and technology over the years. Gordon was very much concerned with the development of a describable teaching methodology to increase the creative output of both individuals and groups. Implicit in this work is an awareness of the importance of a sharing of different individuals' perceptions and observations as a method of injecting differing contributions to a solution to a problem through a group.

However, in spite of claims associated with the plethora of creativity-training programmes operating within many American corporations, consulting firms and colleges, much of this work has been ignored by researchers in the field of problem-solving (Mayer, 1992). Indeed, some of the grand claims have been disputed by researchers within the commercial and industrial context (Taylor, Berry & Block, 1958;

Weisskopf-Joelson & Eliseo, 1961; Dunnette, Campbell & Jaastaad, 1963; Bouchard, 1971; and Weisberg 1986 - all cited in Mayer, 1992).

If we consider the work associated with the development of teaching to facilitate creativity originating from the 1950s and 1960s within the context of current concerns about school-based design and technology, we should note that writers such as Parnes indicated that:

> The *non-creative* problem solver gets an idea, sees it as a possible solution to his problem, and settles for that without further ado. The *creative* problem solver is not satisfied with his first idea. Like the person who invests money to obtain greater rewards later, the creative person foregoes the immediate reward of applying his first idea in expectation of an ultimately better solution (greater reward).
>
> (Parnes, 1970: 349)

Perhaps this indicates a real problem in terms of frustrations expressed by both teachers and pupils when it comes to the syndrome of producing 'six different ideas' on paper before being able to progress along 'the' design process. If we accept Parnes' claim then do we have a deficit of 'creative' pupils (and teachers) operating in school departments?

It is interesting to note the emergence of 'creative problem-solving' (Parnes, 1970; Mayer, 1992) as an amalgam of the two influential concepts of 'creativity' and 'problem solving'. Perhaps this is an indication of the complex mix of ideas within the emerging subject of design and technology.

Society and Change

Justification for such new approaches to education were very much linked to future demands of a technological society, the increasing pace of change, and resultant work-patterns and life-styles. One major consequence of such changing patterns is the erosion of the concept of a 'job-for-life' and the need for adaptable individuals who can change their jobs or careers a number of times.

In terms of the changing requirements of industry, for an increasing number of workers at all levels, from technologists to maintenance and production workers, a flexibility of outlook, the faculty for understanding as well as 'knowing how', an ability to adapt to changing work situations and to absorb new training had become important. Writers such as Postman and Weingartner (1969) and Toffler (1970) indicated the need for a more relevant form of education in response to the changing needs of society and the individuals within it, and the need for a central aim of enabling individuals to 'learn how to learn'. It can be seen that much of this had a direct link to the earlier work of Dewey. Within the context of a 'romantically' inclined 'alternative' stance on the state of education in America in the 1960s, Postman and Weingartner aimed to help all students develop built-in, 'shock-proof crap detectors' as basic equipment in their survival kits with the teacher acting as a 'subversive agent' focusing on creativity and a questioning approach to the challenges of an accelerating pace of change in society. While agreeing in principle with learner-centred problem-based 'inquiry approaches', they were critical of the perceived relevance of examples provided within such work. For instance, they considered that, 'It is almost impossible to find in Bruner's explications of inquiry learning one illustration of children's solving problems that are of deep concern to children, although most of the problems seem to interest Bruner' (Postman & Weingartner, 1969: 60), and in conjunction with others that there is an absence of the consideration of that which is worth knowing within the context of the 'survival of society'. In short, while such commentators agreed with, and supported, the processes of education espoused by the likes of Bruner, they felt that for the most part such forms or processes of education had not been applied to relevant problems in society as perceived by learners.

The 1960s is acknowledged as a decade of considerable innovation and experimentation associated with the teaching of 'productive thinking', particularly in America. Within such programmes there was an emphasis on teaching problem-solving skills within the classroom (see appendix A). Reviews of such 'productive-thinking' programmes and creativity training indicated that while there was evidence of improved performance on problems of similar nature to those featured, and that creativity 'can be trained', it is unclear whether such training and experience can be applied to differing contexts and indeed real-life problems (Mansfield, Busse & Krepelka, 1978, cited in Mayer, 1992). Such evaluative research provides evidence at this relatively early stage of problems associated with claims attributed to problem solving (and transferability to other situations in conjunction with the subsequent concept of situated cognition). Such concern led to the perceived need for more theoretical underpinning of the ways in which people use strategic information in problem solving, an issue acknowledged and developed by writers such as Mayer (1992).

During the 1970s and 1980s there was the subsequent development of 'programmes for teaching thinking', which have continued to flourish, particularly in America, with a noticeable emphasis on problem solving (see appendix B).

In England, there have been a number of attempts to extend the principles of Feuerstein's Instrumental Enrichment within mainstream schools. Two of the most successful have been the Somerset Thinking Skills Course and the Oxfordshire Skills Programme. The most acknowledged of these, the Somerset Thinking Skills Course, aimed at providing at a cognitive resource level course designed to focus on skills considered fundamental to problem solving. In 1980 Somerset Education Authority took part in an exploratory trial of Feuerstein's Instrumental Enrichment programme, concerned mainly with concepts, skills, and strategies involved in problem solving. Feuerstein, inspired by Piaget, believes in the enormous 'plasticity' of the human intellect and focuses on crucial roles played by significant adults in the child's cognitive development. Central to Feuerstein's approach is the notion that a child will reflect on their environment, emphasising and interpreting, but even though the child can be exposed to stimuli they can be cognitively deprived if there are no significant adults controlling these experiences. This programme became known as the Somerset Thinking Skills Course. It is intended to be open-ended and becomes progressively more difficult by making the problems or contexts:

1. More abstract (removed from concrete experiences with a greater use of symbolism; or,
2. Containing greater amounts of information.

There is a focus on problem solving which aims to:

- Reduce impulsivity;
- Develop self-esteem;
- Improve oracy skills (by);
- Working independently or in small groups -
- Enabling the teacher to establish the right kind of working environment for learning, or a term that is frequently used - 'learning to learn'.

Throughout these programmes there is a consistent sense of: teaching component parts of the problem solving process; simulation of 'expert' problem solving; and aiming for transfer to other contexts. As part of an evaluation of creativity-training courses, it raises a number of pertinent issues including:

> ...there is not convincing evidence that global skills can be learned in context-free environments. In short, there is no quick way to improve general problem-solving performance.
>
> This lesson is important for both the teaching and theory of problem solving. First, research on the teaching of problem solving suggests that problem-solving performance depends, at least partly, on a collection of component skills that are directly related to the specific task. Similarly (...) differences between expert and novice problem solvers may be characterised partly by differences in the amount and organisation of knowledge they posses in a particular domain. Second, research on the teaching of problem solving suggests that successful problem solving depends on using appropriate strategies, that is, problem-solving processes are at the heart of successful solutions. Third, research on the teaching of problem solving suggests that problem-solving skills are often applicable only within the domain for which they have been learned. In summary, successful courses provide direct instruction in how to use component skills within specific contexts; successful theories of problem-solving might also need to concentrate on describing the problem-solving processes involved in real-world problem domains.
>
> (Mayer, 1992: 386)

However, in addition to these issues, whenever such programmes are presented or exemplified they tend to be set in contexts other than those with an expectation that whatever pupils 'design' will then need to be 'manufactured'.

The Emergence of Problem Solving within Design and Technology

It is interesting to note that despite the preponderance of manual skills within the historical development of a subject which ultimately became 'design and technology', it has been influenced at times by the desire for a greater degree of 'self-expression' within education (Dodd, 1978). One of the earliest of such influence was that of 'Sloyd' imported from Scandinavia. Based on the working of wood by hand it included, '...situations in which the child had to exercise judgement from a minimum of instructions, and supported this approach by stating that technical achievements were subsidiary to those of an educational nature' (ibid: 20). Attempts were made to introduce Sloyd in England after groups of mainly female teachers were sent to Sweden to see for themselves how it was incorporated within the curriculum. However, it did not become successfully integrated within the English curriculum due to the apparent incompatibilities of conditions and attitudes, particularly where individuals tried to fully institute it. This was despite the similarities in the nature of broad aims of Sloyd and Manual Training in England. Dodd (1978) attributes the difference in interpretation as the major reason for the disparity between the two; despite the commonality evident in stated aims of Manual Training as being, '...to provide opportunity for the development and practice of inventive and constructive faculties; and to afford scope for the imagination' (Barter, 1892, cited in Dodd, 1978: 23). Rather than 'self-expression' the

English approach centred on 'craft' and associated 'craft skills', to the detriment of further educational gains. However, attempts were made to include problem solving within such work. For instance, the introduction to the pamphlet, 'Metalwork in Secondary School' of 1953 states that educational benefits would result from the carefully graded tasks and making of attractive artefacts through, 'discussion, planning, solving problems, tackling difficult tasks and the realisation of the end product' (cited in Dodd, 1978: 27).

In 1964 Donald Porter, staff inspector for handicraft at the Department for Education and Science (DES), spent a sabbatical year researching into links between the 'alternative road' approach and proposed rehabilitation of 'practical education' advocated by the Crowther Report of 1956, which had shown that few bright pupils continued with 'practical/aesthetic' subjects beyond the age of thirteen. The subsequent report was issued two years later, coinciding with moves towards comprehensive education. The report argued for the extension of 'technology' with a greater application of science and engineering into secondary schools. It should be noted that he believed that 'some forms of practical work could be both 'creative' and 'technological' (Schools Council, 1967: xi). Through the consideration of the changing nature of social, economic and educational backdrop, within a context of the needs of pupils and society, Porter considered the changing demands to be made on engineers and technologists in terms of involvement in:

> ...problems which are sociological, economic and even linguistic, and he therefore needs a broader education than is sometimes appreciated, Moreover, he is engaged in a creative profession and it would be extremely useful if, before a choice of career was made, he had been able to show his ability to grapple with actual problems in a creative way.
>
> (ibid: 21)

Links were made to developments in creativity and the process of invention which featured concepts such as 'insight', 'incubation' and 'brainstorming' in conjunction with the solving of real problems and featured amongst Porter's recommendations was, '...that although 'creativity' is still a highly controversial area of research, every effort to discover and to assist the creative youngster should be encouraged' (ibid: 27). A subsequent Schools Council publication on the piloting of Project Technology reported the broadening of technology in a number of the schools to include the moral responsibilities associated with technological 'progress' and subsequent impact on the quality of human life (Schools Council, 1968).

Throughout the historical development of the subject, there has been evidence of tension between so-called 'freer-expression' and 'technical skill' as depicted so well by Dodd (1978) in his analysis on changes of dominant emphases in conjunction with curriculum pressures and evolution (see figures 1 and 2). Even during the early part of the twentieth century there was evidence of reactions against self-expression and elements of 'designing' in Manual Instruction. The Board of Education reported that the involvement in limited freedom and experimentation resulted in an absence of help and guidance and, as a result, the craft-work suffered through a lack of technique and skill. The results of such work was apparently ridiculed by observers of the situation, but, at this time many teachers were apparently ill-prepared for such an approach and misunderstood the heuristic model. Success was being measured solely in terms of the quality of craftwork in the finished artefact - a recurring theme evident throughout the development of the subject. Despite the pressure for a more 'liberal' approach to the curriculum it was not really until the 1970s that the subject responded in substantial terms of providing pupils with opportunity to 'invent' and 'construct' as an intellectual exercise using three-dimensional materials (Dodd, 1978).

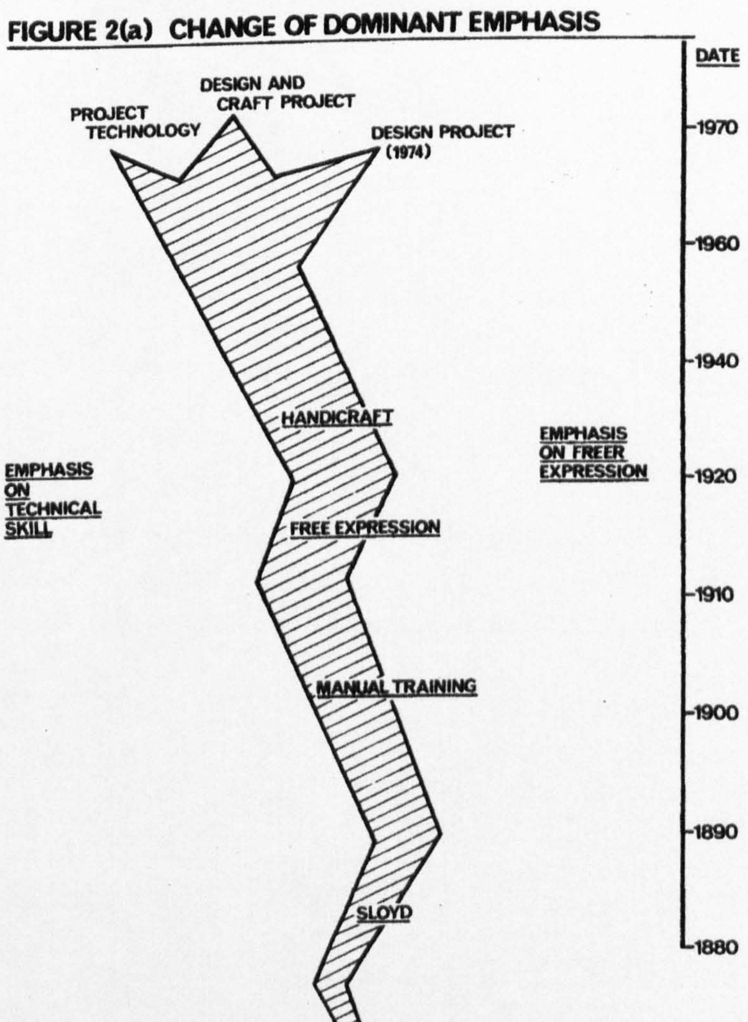

Figure 1. Dodd's Model of Changing Dominant Forces (Dodd, 1978: 29).

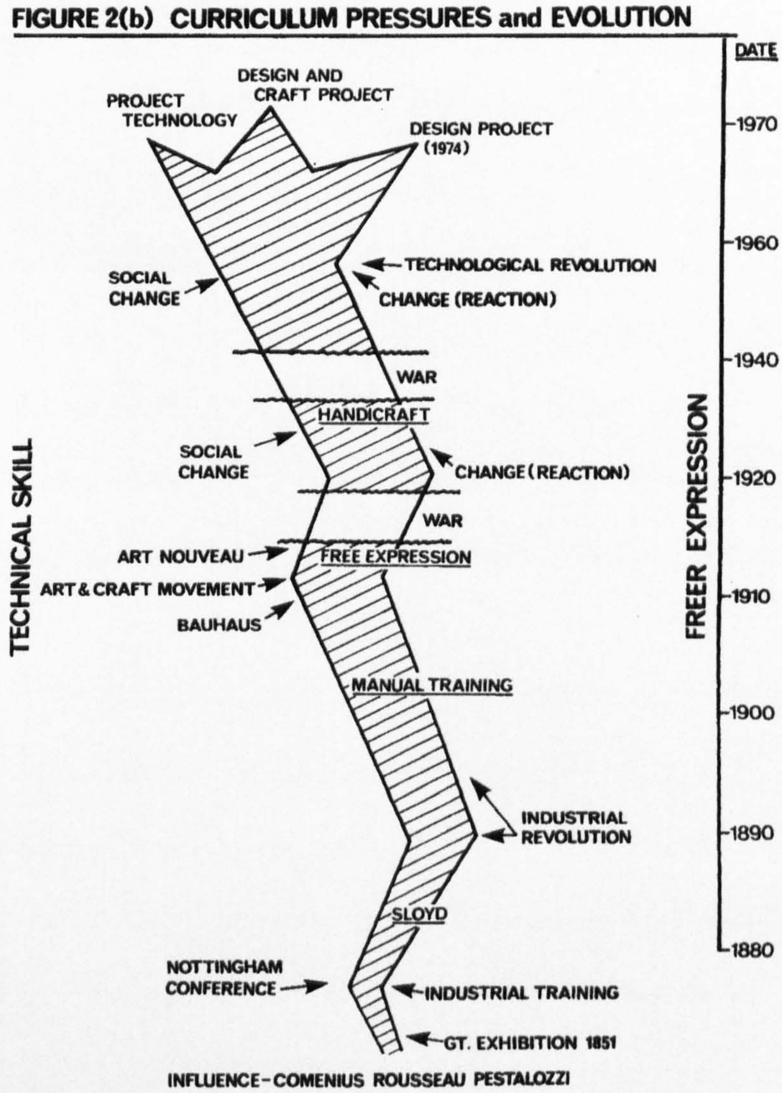

Figure 2. Dodd's Model of Curriculum Pressures and Evolution (Dodd, 1978: 30).

By the 1970s the desire for change culminated in a number of initiatives, of an informal as well as formal nature. Formally, a number of projects were commissioned based in a range of higher education institutions, while informally, a number of 'design departments' emerged within Art and Design faculties in secondary schools as well as the world of higher education. Formal projects included: *Project Technology,* emerging from the earlier work of Porter, based at Loughborough College of Education between 1967-

72; *Design and Craft Education* based at Keele University between 1968-73; *Design Education Research* based at the Royal College of Art between 1973-5; *Art and Craft Education 8-13* based at Goldsmith's College between 1969-72, and; *Arts and the Adolescent* based at Exeter University and Dartington College of Art between 1968-72. The most notable informal developments were within secondary 'design faculties' within Leicestershire local education authority, and the emergence of design education at the teacher training department attached to Hornsey College of Art. In terms of the development of design-based problem-solving methods, Project Technology, Design and Craft Education and Hornsey College of Art were most influential.

Although Project Technology received a mixed response (Dodd, 1978; Penfold, 1987 & 1988), part of its remit involved the development of creative ability allied to a consideration of the 'process of technology', which was essentially a problem-solving activity based on an industrial design-line, with disciplined activity providing opportunities for creative responses (Dodd, 1978). They saw 'total design' as including:

1. the full understanding of the situation which gives rise to the need to be fulfilled;
2. the analysis of this situation for the purpose of synthesising alternative solutions to the problem, using judgements based on technical, ergonomic, aesthetic and practical knowledge and experience;
3. the objective assessment of these alternative solutions;
4. the detailed design using all available knowledge and resources and relying on a developing sense of creativity;
5. the realisation of the design in terms, and lastly a critical re-appraisal to compare the effectiveness of the finished product, or solution, with the original brief.

(ibid: 39)

The model of the 'process of technology' devised and adopted within this project was:

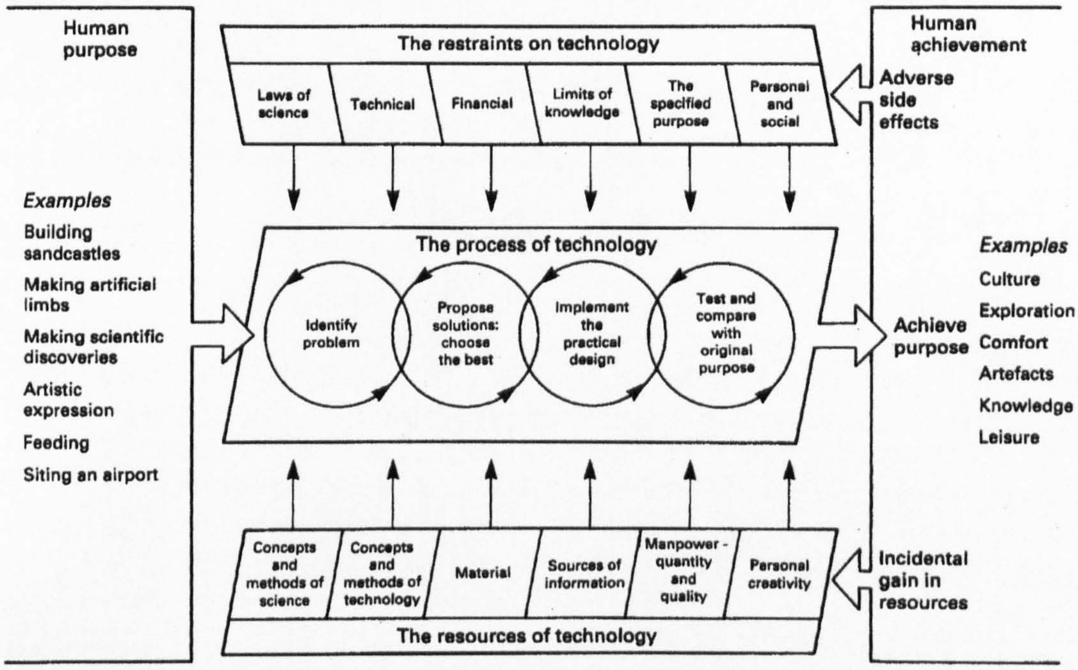

Fig. 2.3 The process of technology – Project Technology

Figure 4. The Project Technology Model for the Process of Technology (Eggleston, 1992: 21).

Despite Dodd's reservations on the relative success of this work as an influential project, he recognised that such a process should encapsulate many parts of the curriculum under the banner of design and relate so-called practical meaning to academic understanding within Rousseau's concept of, 'a practical problem in its natural setting' (Rousseau, 1911, cited in Dodd, 1978: 39). However, there was recognition from a variety of sources, including the project evaluation team, that teachers needed more help in pedagogic issues such as integration of subjects, evaluation, course planning and the organisation of pupil-centred project work within the context of such work. (The work of Project Technology continued through Geoffrey Harrison's move to Trent Polytechnic and the setting up of the National Centre for School Technology.)

The Design and Craft Education project paralleled Project Technology in terms of its focus on 'design'. However, it had a broader outlook in terms of interpretation of the subject area, and applicability to the full range of abilities - utilising activities with materials in a wider context stretching between art, home economics craft and applied science and technology (Eggleston, 1976; Pemberton, 1976):

> Between these limits the project worked in all materials, though developing a special emphasis on the activities based upon woodwork and metalwork shops of the schools and the ways in which they could be developed in a problem-solving context. Its aim was to help students not only to make things but also to experience for themselves the thought processes and the decisions involved in making them, and to be able to relate their experience to their lives outside of the school, in home, work, pleasure and community.
>
> (Eggleston, 1976: 37)

The model of the design process, developed and adopted by the project, reflected a broadening of approach to 'design problems', reflected in diagrammatic model (figure 4), but it should be noted that there was an emphasis on 'creative drive' in terms of an intrinsic motivational objective set within a concept of 'design for living' including design problems focused on real human needs dependent on interaction with users. In assessing the strengths of this project, Dodd (1978), substantiated its educational merit in terms of the inclusion of personal and social relationships related to the 'personable' nature of working with people and Dewey's notion of reflective (critical) thinking and correlated the design process to Bloom's Taxonomy of Educational Objectives. However, when the 'correlation' is relation to a hierarchical cognitive model then it ought to alert practitioners to the level of 'intellectual abilities and skills' needed to operate in such a way in an independent fashion. Despite the influence of the art college foundation course based on the Bauhaus model, it was recognised that the greater emphasis on the problem-solving routine in activities emphasising the functional aspects, (rather than over-emphasis on aesthetic elements) satisfied the existing handicraft and technical studies fraternity. But it was recognised that mistakes were made within some early attempts at basic design courses too closely aligned to expression, freedom and experiment, at the expense of sufficient direction and sense of purpose (Dodd, 1978). This needs to considered in conjunction with concern expressed by others that the extreme conservatism of teachers would threaten such innovation (for example, Dr Eric Briault, Education Officer of the Inner London Education Authority, cited in Dodd, 1978), and teachers' concerns over moving too far too fast (Cameron, 1977) and personal response to the perceived dramatic (pace of) change. However, generally, the logical form and structure of the problem-solving process was accepted with caution but many realised that an unquestioning use of it in its linear format might be dangerous. Indeed, in reviewing the decade of design development up to 1977, Aylward[1] (1977), having previously emphasised the intellectual benefits of practical problem-solving (Aylward, 1973), considered that the simplistic nature of problem solving had by this time served its initial purpose:

> 'Problem solving' is another phrase for a phase that is passing. This served its purpose in concentrating teachers' and pupils' minds on the need for clear thinking about design but the phrase is now seen to be simplistic. Life does not consist of neat 'problems' that can be 'solved'. Instead we are confronted with many 'situations' that can be 'modified' and this is the way design teachers are beginning to think of the activities they promote.
>
> (Aylward, 1977: 12)

[1] Consultative Committee member for the Design and Craft Education Project.

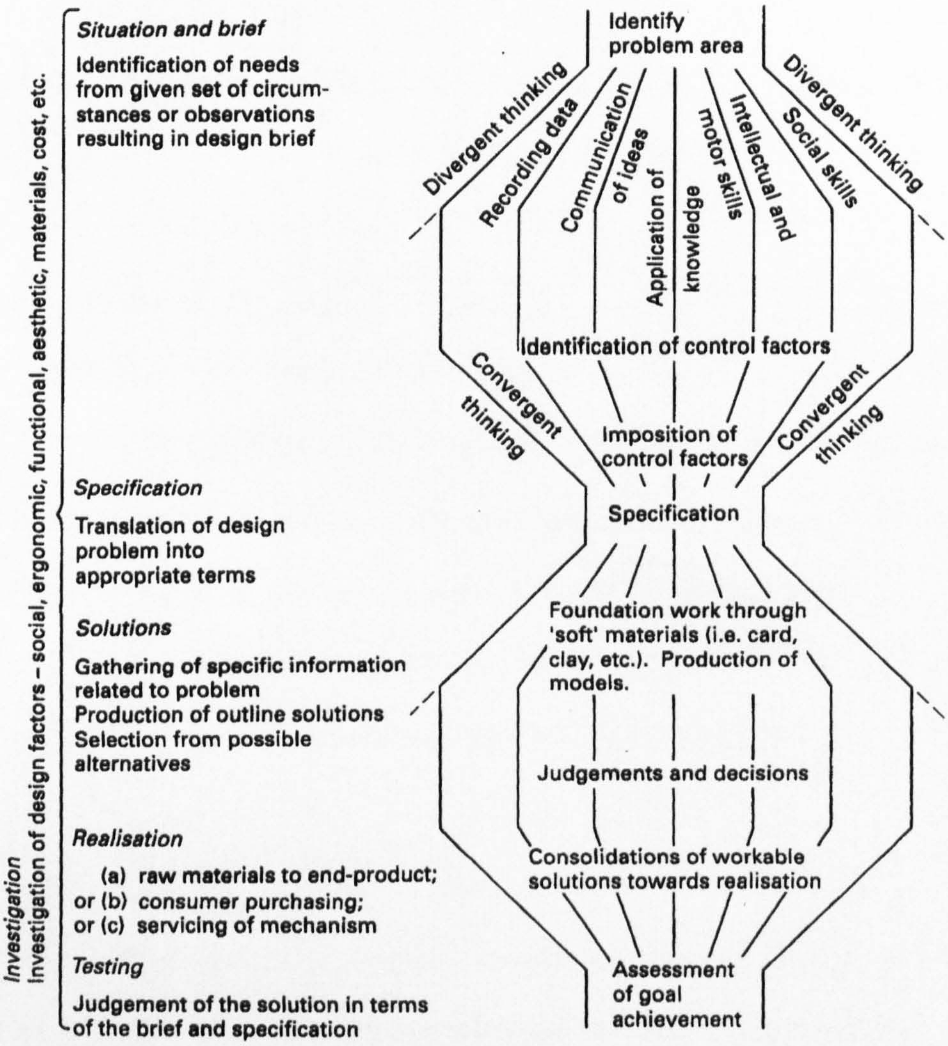

Fig. 2.2 Design process – Design and Craft Education Project (from *Design for Today*)

Figure 4. The Design and Craft Education Project Model of the Design Process (Eggeleston, 1992: 20).

The curriculum objectives associated with the project included:

5. LOGICAL PROCESSES/SRATEGIES

e.g. Deductive/inductive processes
Problem-solving techniques - involving a definite answer
- involving a judgement.

(Schools Council, 1969: 37)

and, indeed such curriculum developments ensured that, 'Problem solving strategies became the order of the day' (Penfold, 1987: 41) and set the scene for the future of the subject.

In retrospect, this project can be seen as a forerunner to 'circus arrangements' as well as the initial conception of the national curriculum. It is also interesting to note the range of issues raised via this project at the time which have subsequently re-emerged during the development of the national curriculum, for instance, the development of 'designing' presented to pupils as problem-solving experiences involving, 'apparently abstract concepts such as need, situation and constraints' (Eggleston, 1976: 39), and the subsequent 'realisation' of ideas (ibid, 1976; Schools Council. 1969).

We can deduce that there was recognition, at this relatively early stage, that it would be intellectually too demanding for pupils to work solely from written or spoken information about the design brief and be expected to generate ideas simply through the medium of drawings on paper ("six different ideas please"), and that it would be more realistic to enable pupils to design through the manipulation of two- and three-dimensional materials. Despite concerns over the adoption to the design process leading to outcomes of a predictable nature, defence of putting all pupils through the seemingly impossible task of developing novel ideas was justified in terms of the educational value from involvement in the process as opposed to the search for originality (Zanker, 1979). This can be seen to link to criticisms levelled at the emphasis on the curriculum in terms of cognition by the likes of Bantock who considered aspirations linked to abstract forms of thought to be beyond the ability of most pupils (Bantock, 1971). The desire for a better balance between 'design' and 'craft' to enable a greater focus on problem solving experiences led some to acknowledge that perhaps it would be more beneficial for scale models, produced to a high level of manufacture, to be produced rather than full-blown solutions, which dominate the educational process in terms of time and 'expense' with an over-emphasis on manipulative skills (Zanker, 1979). Also, it was recognised that the practical problem-solving method advocated necessitates a situation where the teacher is often as much a learner as the pupil, and that, in conjunction with the influential work of Bruner (1977), when this happens then teaching takes on a new quality (Dodd, 1978). Therefore, teachers adopting such an approach need to be aware of, and prepared for, such a change of role.

A perceived growing sense of disillusionment with art teacher training led some departments to reassess the place of practical work within the scope of problem solving and design education. Much of the influence emanated from Peter Green, as Head of the Teacher Training Department at Hornsey College of Art, and Ken Baynes, who were both involved in work with post-graduate art teacher training students, serving teachers and pupils in schools. In 1967 they organised a one-term course for a mixture of art and handicraft teachers and reflected on their shared interest in making teaching more relevant to the contemporary problems. Subsequent developments at the college focused on exploratory programmes or work promoting design education based very much on problem solving. Emphasis was placed on future adults as consumers with a necessary critical understanding and an ability to evaluate appropriateness and efficiency in solutions to problems, and as such:

> All design decisions relate to the problem solving process: the basic process of identifying a problem or need and then testing a proposed solution. Such a process is clearly close to the fundamental processes of creative education in our daily lives. Every day we arrange things around us in ways which are

> really practical solutions to design problems - we arrange tools on benches, utensils in the kitchen, clothes in drawers, so that they can be used efficiently. Experience of problem solving is common to education, the design process and daily life, and is therefore central to any ideas related to design education.
>
> (Green, 1974: 7)

And so we see the addition of 'retrained' art teachers in the development of the subject during a period of relative curriculum freedom and an educational environment receptive to innovation. Against this development, some of the major trainers of technical studies teachers were considered to be stifling such progress (Penfold, 1987 & 1988; Zanker, 1979). In addition to this, Penfold considers that there was a limited response to the changes and developments taking place from local education advisers, despite the work of design education advocates such as Bernard Aylward and Joss Jocelyn. However, the Association of Art Advisers appeared to display a more effective understanding of design education, allied to an apparent willingness to promote such approaches (Penfold, 1987 & 1988).

On completion of the reorganisation of secondary schooling, predominantly based on 'comprehensivisation', discussion ensued on a number of fronts during the 1970s about the purpose of education and the nature of a 'common' 'core' curriculum. During this time, Her Majesty's Inspectorate took the unusual step of publishing a discussion document with the intention of stimulating professional discussion, including consideration of the suitability of curriculum for a technological society allied to a growing emphasis on 'lifelong learning' associated with the importance of initiative, the capacity to solve problems and the ability to get on with other people. They proposed an overarching title of 'technology' as, 'the rational application of science to the human condition' (Her Majesty's Inspectorate, 1977: 30), in addition to the subject of 'craft, design and technology'. Within the concept of technology they proposed that:

> Technological change will increase, processes and techniques of work will be more quickly out-dated. The body of knowledge will grow and syllabuses will have to become more selective. There is a need therefore to develop in everyone a capacity for the acceptance of retraining. If schools are to make pupils capable of continued learning, there is a strong case for:
>
> i. Reconsidering the balance in the curriculum between factual knowledge, concepts and skills.
> ii. Equipping every pupil with techniques of independent study to strengthen those skills which help in the assimilation of new knowledge.
> iii. Emphasising at an appropriate stage problem-solving techniques in all subjects.
>
> (ibid: 11)

Within the subject of craft, design and technology they emphasised cognitive development with its central aim, '...to give girls and boys confidence in identifying, examining and finally solving problems with the use of materials' (ibid: 33). As part of an apparent change in emphasis of purpose, it was considered that, 'Craft, design and technology is concerned more with the development of desirable attitudes than with an end result or with the acquisition and retention of a specific body of knowledge' (ibid: 34). Interestingly, the final 'expectation' for the subject suggested that, 'Some but not all pupils, by the age of 16 years, will be able to identify and analyse a real problem and to produce a well-made solution which satisfies the need' (ibid: 35), which, one imagines, may be a recognition of cognitive demand and depth of intellectual ability required for such work.

Subsequently, the Department of Education and Science (DES) published a *Framework for the School Curriculum* with craft design and technology (CDT) exempted from the proposed core curriculum, although it did feature, with other subjects, as important in preparation for adult and working life. This signalled a period of changing fortunes in the status afforded to the subject of CDT. The aftermath of Callaghan's Ruskin speech of 1976 reflected an increasingly centralised interventionist approach to education as well as concern over a 'failing' education system and curriculum, leading to a greater emphasis on links between education and industry, and so-called vocational education, with the inevitable consideration of the importance of CDT in terms of national industry and commerce. So, while CDT was centre-stage in the 1976 Green Paper (Penfold, 1987 & 1988), this was arguably at the cost of its merit in terms of academic status, due in part to the narrow interpretation of its close alignment to industry's needs. However, within the development of pre-vocational courses and the Technical and Vocational Education Initiative (TVEI)[2] there was, however, an intention to improve relevant and transferable skills and the concept of 'learning to learn'.

During the 1980s a number of reports and publications emanated from various councils as well as Her Majesty's Inspectorate in an attempt to re-establish or further the status of CDT in education. During this time we begin to witness a diverse range of perspectives and influences on the subject from organisations such as The Design Council and The Engineering Council. For many these confused emerging consensus of the nature and 'content' of the subject.

The Design Council's view was that there should be a new subject called design which would encapsulate a range of existing subjects such as art, CDT and home economics

[2] An initiative introduced in 1983 in England and Wales for 14- to 18-year-olds which emphasised vocational and technical education and preparation for working life. The project, under the auspices of the Manpower Services Commission (MSC) was financed by the Department of Employment, by-passing the Department of Education and Science in order to circumvent the legal restrictions of the 1944 Education Act.

with support derived from mathematics, English and science. Design was seen as important in terms of a general education for all pupils up to the age of sixteen, as well as those who might enter a related profession. 'It should encourage creativity and develop the skills of problem solving, decision taking and evaluating, all of which are valuable in adult life, while generating an awareness of the qualities of the man-made world' (Design Council, 1980: 5). The emphasis was on art, craft and design activities which would involve pupils in, 'the creative examination of problems concerning man's relationship with his environment' (ibid: 6), and that such design activities would:

> ...have in common the aim of giving pupils experience of:
>
> - examining a given problem or situation in order to identify and state the opportunities and difficulties involved;
> - undertaking research and compiling data on the problem or situation and the factors affecting it;
> - analysing the information gained;
> - preparing a brief against which design proposals can be tested, so as to overcome the difficulties identified;
> - proposing responses to the brief and choosing the most appropriate;
> - developing this response and, where appropriate, bringing it to some practical conclusion;
> - analysing and evaluating the results and communicating this to others.
>
> (ibid: 6)

In regard to the concept of problem solving, design education must:

> (e) provide a graduated programme of engagement with real or realistic problems in the conception, making and use of a variety of man-made things;

(f) demonstrate the ways in which a combination of analytical, inventive and practical skills can be used to create an effective match between users' needs and producers' resources;

(g) encourage the capacity for constructive criticism and evaluation, and particularly criticism of the pupil's own efforts;

(ibid: 10)

Part of the Design Council's remit was the lobbying of Higher Education to recognise design courses at A level on a par with other subjects, through their intellectual rigour and merit. It considered that the acquisition of the knowledge, skills and concepts involved in design is intellectually demanding, while acknowledging the extent of transferability of such skills would depend largely on the style of teaching, but that, 'The teacher's aim should be to encourage pupils to think objectively about the factors governing choice (of materials, for example) and to consider problems in their whole social, technological, economic and aesthetic context' (ibid: 7). However, criticism was levelled at the idea of implementing a linear professional design model within an educational framework, or the imposition of, 'a pupil-as-designer framework on to the pupil-as-learner' (Baines, 1980: 6). Also, the absence of a theoretical framework in terms of cognitive development and design-educational activity reflected a prescriptive model which, if readily accepted by education, could lead to perceived failure and the 'scapegoating' of teachers involved (Roberts, 1980).

During the same year Her Majesty's Inspectorate promoted a somewhat restrictive view on CDT within the booklet: *Craft, Design & Technology in Schools: Some Successful Examples*. The stated emphasis was on Her Majesty's Inspectorate's recognition and promotion of 'good quality' and was encapsulated in the comments on 'craftsmanship' and 'design', which focused very much on the quality of finished artefacts and the application of design in terms of sketching and modelling. In relation to the focus of other projects and reports:

> The arguments advanced by teachers for design education in schools are not principally those of vocational relevance, or of consumer education, or even of education for leisure. Rather, there is a belief in the value of designing, and the corollary of making, as a unique and worthwhile intellectual activity in its own right.
>
> (Department of Education and Science, 1980: 31)

This publication could be seen as very much a reflection on historical success, as opposed to future development of the subject, with no discreet reference made to problem solving.

A subsequent booklet published by Her Majesty's Inspectorate, entitled: *Technology in Schools: Developments in Craft, Design and Technology Departments*, explored the notion of technological studies within the curriculum in general courses in CDT or in special courses considered to be peculiarly 'technological'. Acknowledgement was given to the influence of technological problem solving within the Schools Council's projects Project Technology and Modular Courses in Technology. Part of the purpose of this publication was associated with the need and desire for a definition of 'technology', whose absence, it was considered, 'does nothing to advance discussion of the topic in schools' (Department of Education and Science, 1982: 16). Featured within it, in response to the question of "how do you define technology?", teachers did include, 'It is a creative *process* of using human knowledge and physical resources to solve *practical problems*' (ibid: 16). An emerging consensus was that of improved status through the adoption of technology (as opposed to traditional courses in woodwork and metalwork) considered more relevant and challenging to pupils, parents, head teachers and employers. However, the publication summarised the reasons for the inclusion of technology in the curriculum as, '...curiously fortuitous and attributable to the experience or enthusiasm of a particular teacher, head or LEA[3] adviser but rarely to overall curriculum planning' (ibid: 18). Although we can see the inclusion of discussion associated with the process of CDT, it seems that the more dominant concern was the content of the subject. When the process of designing or problem solving is raised it is presented as a 'given' without the need for educational or pedagogical exposition.

The Schools Council's working paper on *The Practical Curriculum* (in terms of the practical consideration of the curriculum - not the practical elements of the curriculum) further emphasised the need for pedagogical consideration within its discussion of planning for a common core curriculum. In addition to its support for the involvement of problem solving in a general sense and CDT as a compulsory subject in the curriculum, in relation to the importance of involving different 'modes of teaching and learning' it was maintained that, 'Teachers find it as hard to know how to teach as to know what to teach' (Schools Council, 1981: 20). Further to this, assuming the inclusion of problem solving within the concept of 'skills', the council emphasised the development of skills in terms of effective teaching focusing on types and levels of skills in terms of precise aims within curriculum planning (ibid).

In a further attempt to clarify the nature of CDT, Her Majesty's Inspectorate produced a paper entitled: *CDT: A Curriculum Statement for the 11-16+ Age Group*. This provided teachers with a further, more detailed, version of the 'design process' through the identification of what a course in CDT should enable pupils of all abilities to do:

[3] 'LEA' - Local Education Authority

i. tackle an appropriate problem;

ii. analyse the nature of that problem to determine the exact requirement;

iii. identify, and collect appropriate data;

iv. apply relevant knowledge to the problem;

v. initiate, develop and then communicate design proposals to others using any appropriate technique;

vi. decide upon and detail the most appropriate solution for development;

vii. plan the method of production;

viii. make the solution to the standard required;

ix. monitor progress throughout the manufacture until a satisfactory conclusion is reached;

x. evaluate both the efficacy and the overall quality of the designed solution, be it a product or a system, and suggest lines for future development, should improvement be desired;

xi. record the development of the project.

(Her Majesty's Inspectorate, 1983: section 2)

Within this paper it states that the title of craft, design and technology implies that, 'the activities involved are those of cognitive and manipulative skills inherent in designing and making' (ibid: Section 1), and so we begin to see at this stage of evolution the inclusion of skills in terms of both manipulative skills and cognition. Although problem solving within designing and making is prevalent throughout the paper, and responsibilities of teachers are made clear, it does not go much beyond the general principles of any hierarchical structure associated with cognitive development. Although a purpose of this paper was to generate discussion in the form of a preliminary contribution to the subsequent second edition of Her Majesty's Inspectorate's booklet "Curriculum 11-16", it seems there was a need for a greater consideration of pedagogical issues associated with the design-based problem solving process and appropriateness of teaching in terms of teaching styles and the setting of projects, in order that practitioners were more fully informed and confident. Such an inclusion would also balance the pragmatic aspects of teaching CDT in terms of practical skills with the needed injection of educational considerations.

Any tracking of in-service training during this phase of development of the subject seems to reveal a focus more on subject content, 'practical skills and processes' than issues associated with effectiveness of teaching in a more educational sense. In fairness to teachers, this would always tend to be a priority due to the appeal of such work and their sense of need as teachers with appropriate practical skills to impart.

The subject of CDT was further promoted through a series of exhibitions, publications, papers and statements form various pressure groups. For instance, an exhibition entitled: Designing and Making was officially opened with the support of the Secretary of State for Education and Science, Sir Keith Joseph in Leeds in 1985. This travelling exhibition was organised by a regional consortium of advisers in CDT with the purpose of drawing attention to the importance and educational merit of designing and making throughout the whole period of formal schooling. Links were made between 'designing and making' and 'problem solving', which present a subtle variance on the idea 'that pupils would benefit from participating in solving problems, through design' (Dodd, 1983: 55), with design being the 'integrating process' (ibid), and it is interesting to note the distinctions made between different stages of education, in that the general description of designing and making:

> ...may give an impression that designing and making is the same thing as problem solving and that interpretation would seem reasonable for many of

> the activities that occur in the primary school. From about the age of ten, however, the solving of problems occurs at many points and in different ways within the more extensive process of designing.
>
> (East Midlands and Yorkshire Forum of Advisers in Craft, Design and Technology, 1985: 3)

Throughout the publication there was considerable evidence of the promotion of the subject emphasising intellectual demand, and consequential desirability within a 'compulsory curriculum'. The general introduction refers to the great deal of research into the broad features of children's creative development. Within secondary education, it is argued that with the additional encounters with technical facilities, 'pupils reveal an increasing capability to think in the abstract' (ibid: 22). The complexity of conceptual experiences encompassed by the subject are exemplified within the section on designing, which considers design in terms of: a process of thought and action; as a mental process, and; as an operational process linked to problem solving. (ibid, 1985)

One can see, and recognise why, such a complex picture is presented within such a forum. However, do we seem to witness another example of having to 'over-egg the pudding' to justify the existence of a subject within the curriculum with a history of low status and a history of division between the so-called 'academic' and 'practical/applied' areas of knowledge.

During the 1980s a considerable amount of 'output' emanating from Her Majesty's Inspectorate concerned itself with responses to the so-called 'great debate' initiated by Callaghan. This developed through to a consideration of areas of learning and experience within a common core curriculum for pupils between the ages of five and sixteen which was still reliant on the 'delivery' of subjects at secondary level. Much of this was supportive of the position of CDT and its link to pupils' subsequent ability to solve real-life problems as adults. In 1985 they proposed that the curriculum be based on the following areas of learning and experience:

> aesthetic and creative
> human and social
> linguistic and literary
> mathematical
> moral
> physical
> scientific
> spiritual
> technological
>
> (Department of Education and Science, 1985: 16)

These were not to be considered as discrete elements to be taught separately and in isolation from one another; but instead as a planning and analytical tool. Although not intended to be equated with particular subjects, they did acknowledge that a considerable amount of the technological area of learning and experience could be seen to link to CDT and the physical sciences in terms of 'total process'. Furthermore, within the description of this area of learning and experience, it was considered that:

> The essence of technology lies in the process of bringing about change or exercising control over the environment. This process is a particular form of problem solving: of designing in order to effect control.
>
> (ibid: 34)

Within the secondary school phase such confidence to 'control things' should be growing, and, 'There should be a qualitative change in the process of solving problems' (ibid: 35) beyond the prior experience encapsulated in the concept of 'making things work better'. By the secondary stage, progression is seen in terms of the fact that:

> The activity of designing should have become systematic and should progress from problems in the immediate environment to those which are more remote such as devising ways of saving fuel in school or the automatic watering of plants during the school holidays. Designing should also include a more through analysis of the problem, including such essential aspects as fitness for purpose and cost in production and use. There may be a greater necessity for gaining knowledge and skills which are not already possessed, or utilising what is learned in several subjects.
>
> (ibid: 35 & 36)

Bearing in mind the subtle distinction between 'subject' and 'area of learning and experience', it was suggested that the process of solving a problem within designing need not lead to the manufacture of an artefact (ibid).

'Elements of skills' were considered in terms of 'knowledge', 'skills' and 'attitudes', and problem solving was featured within skills, where, 'A skill is the capacity to perform a task' (ibid: 38). Progression was proposed as a hierarchical structure implying that problem solving should be at the top, for instance, 'On another plane skills may involve the application to different tasks of complex thought processes drawing on understanding and abilities of a high order' (ibid: 39). For expressed convenience, problem solving appears as a group of the following sub-skills:

> to ask pertinent questions
> to propose alternative hypotheses and to help to design ways of testing them
> to carry out fair tests
> to apply knowledge and concepts to the solution of real-life problems
> to predict on the basis of experience and data
> to make informed choices
>
> (ibid: 39 & 40)

Furthermore, in relation to teaching, 'In developing problem solving skills, teachers have the important task of helping pupils to tackle problems analytically and to adopt logical procedures in solving them' (ibid: 40 & 41). While such advice seems to support the adoption of some form of 'design problem-solving process' within CDT based on the model of 'design and make', difficulties over potential conflict begin to appear in the form of the imperative that:

> At the same time pupils must be allowed to make mistakes and to follow false scents in what is essentially an exploratory process; and the teacher has to resist the temptation to give the 'right' answer, or to over-direct the pupil, otherwise the skill is not developed or practised.
>
> (ibid: 41)

Associated issues had been raised by others who advocated an approach based on the solving of problems within design, where there was recognition of the fact,

> ...that pupils must grapple with practical problems from the beginning even though they lack some of the supporting knowledge. (The more formal strategies for acquiring knowledge need supplementing with 'need to know' inputs)
>
> (Dodd, 1983:55)

and,

> that pupils must be encouraged to accept risks as a normal part of designing (...)
>
> ...The teachers' dilemma must always be to balance support against freedom because creativity will not flourish in a restrictive environment, nor will efficient learning take place in a laissez-faire atmosphere
>
> (ibid:55)

However, such issues increasingly caused difficulties within the teaching of CDT in terms of existing teachers feeling confident in their new range of roles - including being 'learners' themselves. Associated concern had been raised earlier by Down's questioning of such an approach and the transition from teachers in transmission mode, in that:

> ...when the problem is allowed to go beyond the teacher's present knowledge and skills, he has to use resource material and to find out information or to practise new skills. There is a sense, therefore, in which he is placed in a more vulnerable position, his knowledge no longer being superior to his students. In this situation he needs a more general knowledge than the average subject teacher and he has to be willing to expose his ignorance and to learn occasionally from his students.
>
> (Down, 1983: 41 & 42)

Teachers were encouraged to consider the concept of 'why CDT' as opposed to 'how CDT' in preparation for such changing roles and it was suggested that if properly used, '...recently developed technical aids of cognitive modelling are a great help to pupil and teacher alike, but they need to be seen as aids rather than as alternatives' (Hicks, 1984: 47). Nevertheless, after recognition of the fact that, 'Some of our teachers are not yet at ease with design teaching' (ibid: 48) associated consideration of in-service provision concentrated on the 'how' in terms of the handling of visual and aesthetic awareness as well as new practical processes, materials and techniques associated with CDT.

After lengthy debate, the government announced its intention to legislate to establish a national curriculum. As part of the ongoing contribution to such debate, Her Majesty's Inspectorate published a series of subject specific documents to stimulate discussion on the component 'parts' of such a curriculum. From the CDT publication emerged the 'design loop' (figure 5), which while going beyond the strict interpretation of a linear process, could be described simply as a 'curved linear process', as in graphical terms it still implied a step-by-step approach.

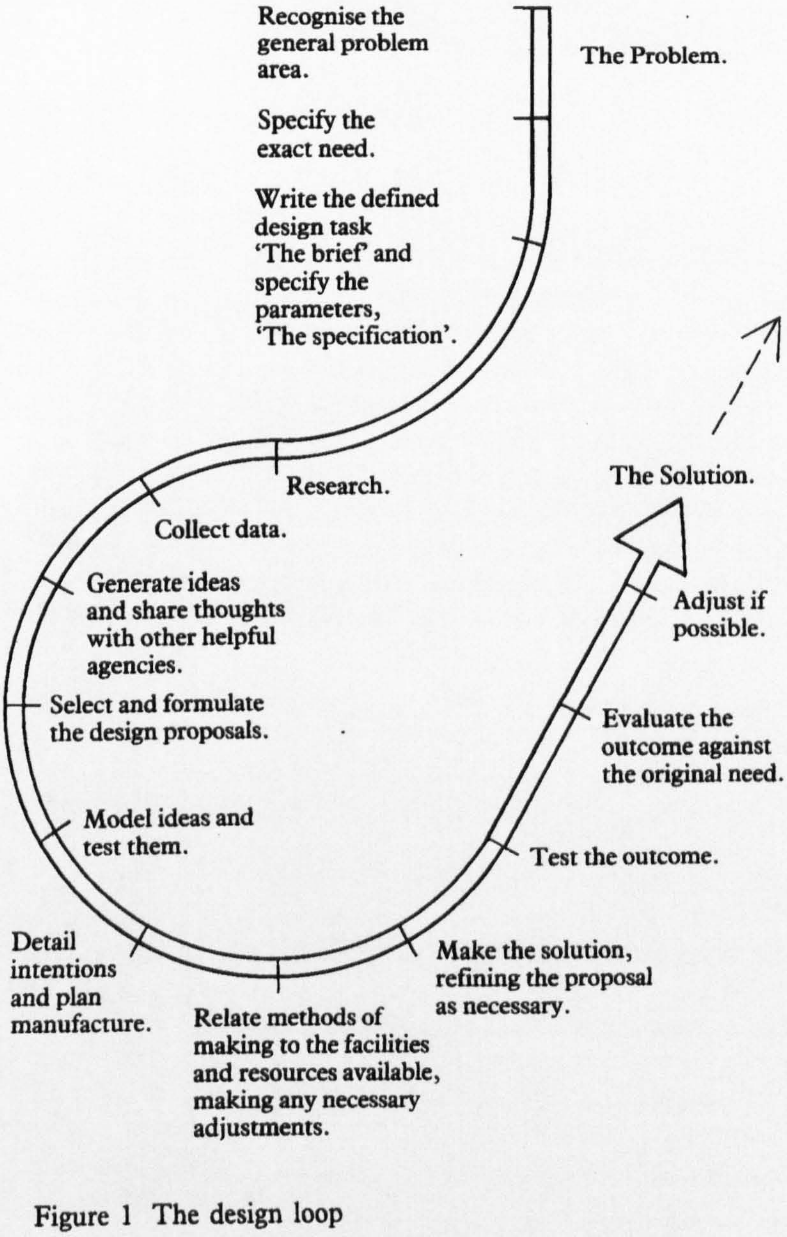

Figure 5. Her Majesty's Inspectorate's Presentation of The Design Loop (Department of Education and Science, 1987: 10).

Earlier observations reflected on the fact that while teachers adopted various versions of the so-called design line and followed them through a clearly laid-down process from brief to evaluation, 'For some teachers this is too restricting: some would argue that a creative response is not possible where such rigid guidelines are given; others would argue that only by giving clear limits can the work progress' (Forrest-Smith, 1980: 87). Within the then current CDT curriculum publication it was recognised that, 'Designing seldom proceeds by way of a series of clearly recognisable stages to a neat solution' (Department of Education and Science, 1987: 9), and that the model:

> ...claims to do no more than to illustrate a logical progression in carrying through a design proposal. Certainly it should not be regarded as a rigid framework to be applied in all cases, but rather as a set of reminders of what might be involved. Within the framework, there is provision to work analytically and methodically, or empirically and intuitively, or with a combination of all of these. Many pupils, both in primary and secondary schools, are able, perhaps because of particular experiences or abilities, to move more rapidly through some stages or to leave them out altogether. (...) The loop therefore provides a notional framework which needs to be used with the utmost flexibility. By and large, the greater the flair a pupil has in CDT, the more he or she will exploit that flexibility.
>
> (ibid:11)

While there is recognition that, '...deciding the approach to a problem or the sequence in which work should be carried out is often a much harder task than producing the finished article or system (...) (ibid: 19), there is an absence of much discussion about specific pedagogical issues in terms of the process of teaching and learning as opposed to that needing to be covered and assessed within such the subject of CDT. This 'working paper' was received very well by the CDT community, as exemplified by the positive support expressed by the Association of Advisers in Craft Design and Technology, which mapped out links to all aspects of the initial generic document on the five-to-sixteen curriculum. In addition to this the advisers obviously endorsed the concept of a technological area of learning and experience which they likened to 'technological capability' and saw CDT as the main, but not sole, contributor to this (Association of Advisers in Craft Design and Technology, 1987).

The Development of National Curriculum Technology

In response to Callaghan's Ruskin College speech in 1976 and the subsequent seeking of consensus for a school curriculum which would 'develop the potential of all pupils and equip them for responsibilities of citizenship and for the challenges of employment in tomorrow's world' (Department of Education and Science/Welsh Office, 1987: 2), the need for a national curriculum was identified. Many developments ensued during the period between 1987 and 2000 reflected by a proliferation of publications (see appendix E).

With the hindsight of adopting 'problem solving spectacles' it is very noticeable that throughout this historical/chronological account there is practically no overt mention of problem solving in particular[4], and a general absence of 'pedagogical discussion'. It may be argued that this was the case with the equivalent documentation for the other subjects within the national curriculum; however, within the context of the initial 'liberal' and holistic interpretation, technology was promoted as an under-researched 'new subject' of a complex nature (Department of Education and Science and the Welsh Office, 1988) which described it as, 'a way of working...' (National Curriculum Council, 1990: A1). The initial proposals 'which received widespread support' (Eggleston, 1992: 29) did, however, develop the recognised liberal philosophy further in terms of considering, 'the

[4] A similar exercise was conducted by the PSTE (Problem Solving in Technology Education) research team at the Open University, which reflected the relative lack of inclusion of 'problem solving' – see appendix D.

development of design and technological capability "to operate effectively and creatively in the made world" as the overall objective for the subject' (Department of Education and Science and the Welsh Office, 1989: 1) consequently helping, 'pupils to develop a flexible approach to the problems and opportunities they will face in a rapidly changing society' (ibid: 1). It was recognised that many of the problems that pupils would be likely to face in their personal and working lives would have a technological dimension and that, 'equally the means of solving them, of operating effectively in fields where there is not one right answer, where judgement as much as technique is the hallmark of successful practitioners, depends upon design and technological capability' (ibid: 7). An implicit causal relationship between involvement in the proposed national curriculum subject and the ability to solve problems is typified by a statement tucked away in an appendix where the working group viewed, 'technology as that area of the curriculum in which pupils design and make useful objects or systems, thus developing their ability to solve practical problems' (ibid: 93).

From such relatively erstwhile beginnings, the subsequent development of the subject was dominated by concerns over issues such as what should be included in the subject as well as the quality of manufactured products and artefacts, at the expense of pedagogical consideration. In conjunction with 'political expediency' over the establishment of design and technology in the curriculum, such issues associated with epistemological complexity did not feature significantly (Roberts & Norman, 1999).

Explicit attention to problem solving appears in the latest incarnation of the subject, but ironically this has emerged from outside of the subject via the inclusion of 'key skills' across all subjects, quantified in terms of the generic key skill of problem solving promoted through design and technology, 'through dealing with conflicting requirements when making and project planning, and through considering alternatives in designing when investigating and evaluating products' (Department for Education and Employment and the Qualifications and Curriculum Authority, 1999: 8). This is developed further in the Qualifications and Curriculum Authority 'scheme of work' for key stage 3 design and technology (to be) presented within the teacher's guide for the national curriculum in 2000:

> In design and technology, problem solving can range from ad hoc ingenuity in making to strategic project planning and the consideration of significant alternatives in designing. Particular ways in which pupils can develop their problem solving skills in this subject include the sorting, comparing and analysing of data or information, researching; understanding patterns or seeing connections; preventing hazards; recognising issues; sequencing; recognising different factors; explaining the workings of a system or design features; formulating and testing ideas; suggesting approaches; selecting options; predicting or making judgements and decisions and justifying their reasons and arguments; applying their ideas in a creative way, both in innovative designing and in ingenious making; developing criteria for product success, and refining ideas and evaluating their products.
>
> (Davies, 2000: 168)

Interestingly, positive links are subsequently made to raising awareness of 'thinking skills' linked to creativity and problem solving. For example, it is suggested that a class debate could be instigated on the derivation of new ideas involving deliberate strategies for generating new ideas such as, brainstorming, analysing products, using part of a visual image, taking everyday objects and thinking up new uses for them, instant modelling with a variety of materials (ibid). Furthermore, teacher reflection on learning styles and thinking skills is considered central to such developments in concert with pair problem solving, cooperative learning and group discussion (ibid).

The Concept(s) of the Teaching and Learning of Problem Solving

> It is strange that we expect students to learn yet seldom teach them anything about learning. We expect students to solve problems yet seldom teach them about problem solving. (...) We need to develop the general principles of how to learn, (...) how to solve problems, and then to develop applied courses, and then to establish the place of these methods in an academic curriculum.
>
> (Norman, 1980: 97)

Reflection on the historical development of problem solving within designing and design and technology suggests that much influence has come from the world of commerce and industry. In relation to the teaching (and learning) of problem solving and the relationship between school and subsequent life- and employment-skills, it has already been noted that there has been a tendency towards falseness of problem posing and consequential problem solving, as opposed to the handling of problems in the 'real world' (Duckworth & Lewin, 1981). When considering the concept of the teaching of problem solving, there must be awareness of the context and type of problem solving we are to be concerned with. We should be wary of directly importing teaching and training principles and models from industry to the world of secondary education. Also, we need to reflect on the adoption of principles from inappropriate types of problem solving, such as mathematical problem solving based on algorithmic strategy, as opposed to creative open-ended problem solving based on heuristic strategy.

It has been suggested that it would be desirable to develop within individuals a generic ability to solve problems which could then be applied within different contexts (Cyert, 1980; Hayes, 1980). Proponents of such an approach support the claim that general problem solving courses can, and do, lead to improvement within specific contexts ranging from life-choices to educational projects such as designing an educational game

(Rubenstein, 1980). Frederiksen (1984) compiled a list of 10 heuristics as presented by Cyert (1980):

1. Get the total picture; don't get lost in detail.
2. Withhold judgement; don't commit yourself too early.
3. Create models to simplify the problem, using words, pictorial representations.
4. Try changing the representation of the problem.
5. State questions verbally, varying the form of the question.
6. Be flexible; question the credibility of your premises.
7. Try working backwards.
8. Proceed in a way that permits you to return to partial solutions.
9. Use analogies and metaphors.
10. Talk about the problem.

(Frederiksen, 1984: 372)

Adherents of such an approach maintain that general development in terms of cognition does have a positive effect on subsequent specific subject contexts, for instance (Ashman & Conway, 1993; Adey & Shayer, 1994). However, critics of such an approach cite difficulties over the differences between algorithmic and open-ended problems. As problems become more complex, there is a greater need for context-specific knowledge, and consequently individuals might become, 'quite good general problem solvers, as long as they deal with relatively simple problems' (Reif, 1980: 40). Also, the ability for individuals to transfer from one context to another is questioned in terms of the concept of 'situated cognition' (Hennessy, 1993; McCormick, et al, 1996b). In response, advocates of transferability call for balance - for example, 'effective professional education calls for attention to both subject-matter knowledge and general skills' (Simon, 1980: 86). Johnson (1997) considers that specialised 'thinking courses' based on the belief that thinking can be divided into specific skills that can be taught and then combined into larger applications of thought is too simplistic in approach. In conjunction with the work of Newell and Simon (1972), such an approach 'fails' because it ignores the importance of subject/content knowledge as identified through cognitive research, and, as such, thinking skills cannot be taught in isolation from content and context.

A further categorisation of problems and consequential problem solving has been proposed by Scriven (1980) which raises associated pedagogical issues. Building on the concept of algorithmic and open-ended problem and problem solving, Scriven hypothesises a typology based on three types: 'problems of the first kind', or '*within-paradigm* problems' typified by mathematical or physical problems and game problems; 'problems of the second kind', or '*new-paradigm* problems, typified by most puzzles and 'concept' learning tasks, requiring a 'new' approach, and; 'problems of the third kind', typified by problems within humanities and practical spheres of education, which involve different cognitive and pedagogical difficulties. Such difficulties associated with third type problems have been seen in terms of their sense of 'realness' and being 'positively' and necessarily underspecified, ill-defined or ill-structured, with a potential danger of teachers therefore castigating their value within teaching in subjects such as design and technology (D&T) in schools.

In association with such classification of problems, it is extremely important that the level of problem devised for learning is appropriate (not too hard or indeed too easy) and that aspects associated with 'structure' are relative to the problem solver. Therefore, there is a need for insight into the relative strengths and levels of operation of the individual students and greater understanding and practice of differentiation and progression. If such an approach were to be based on levels of operation then cognitive levels of operation need to be considered. However, we should be reminded of the teacher's role providing 'scaffolding' within Bruner's model of a spiral curriculum allied to his contention that, '...any subject can be taught effectively in some intellectually honest form to any child at any stage of development' (Bruner, 1977: 33). In addition to this, we ought to consider the teacher's task of 'expert intervention' within Vygotsky's concept of the Zone of Proximal Development (ZPD) (Cole, et.al., 1978; Smith & Cowie, 1991), and more specifically, in terms of problem solving, Feuerstein's Instrumental Enrichment (IE) system where he considers problem solving as a Mediated Learning Experience (MLE) with the teacher deliberately intervening to help the learner interpret and organise events so that they move on to becoming independent problem solvers (Feuerstein, et al., 1981; Glover, Ronning & Bruning, 1990). Ways in which tasks are presented and in turn operationalised by pupils will influence performance. There is a role for teachers in interpretation of 'abstract' knowledge and facilitation of any necessary prioritisation of such knowledge in order that it might be successfully utilised (Jones, 1997).

However, in terms of the nature and characteristics of the problem themselves:

> There is no sharp division between well-structured and ill-structured problems. Simon (1973) concludes that ill-structured problems are often solved by being simplified into a series of small well-structured subproblems: "The problem is well-structured in the small but ill-structured in the large" (p. 190).
>
> (Frederiksen, 1984: 366)

In addition to this, that which seems to be ill-structured to one individual might not be to another. Variables include possession of requisite knowledge and experience in relevant problem-solving procedures (ibid). In general terms though, the complexities of problems as given to pupils in, 'most classroom approaches do not reflect actual technological problem solving which involves mainly adaptation and modification rather than starting from scratch' (Hennessy, McCormick & Murphy, 1993, cited in Jones, 1997: 88). From another perspective:

> The openness of the activity can also affect student learning of technological concepts and processes. The more open and large the task might be (e.g., designing a playground), the more the students can end up getting lost with the multiple demands of the technological problem (Jones & Carr, 1993; Jones et al., 1995; and Kimbell, 1994). For example, students may select a task where they approach the solution in a superficial manner and not allow for technological principles to be incorporated. Students who tried to consider large problems often concentrated on organisational aspects rather than developing and incorporating technological approaches to their problems (Jones & Carr, 1994). The opposite situation is also true where if a task is closed (i.e., closely defined), then this can limit students' approaches and affect the potential to learn and incorporate technological principles. This is often found where students are constrained by a defined design cycle, where resources and outcomes are identified. This can also limit innovative approaches that students might have to technological solutions and limit the learning of technological principles, such as modifications, adaptations.
>
> (Jones, 1997: 89)

In terms of the predominance of 'the design process':

> Jones & Carr (1994) found that when students had been taught a closely defined design cycle approach they followed this step by step in a superficial manner and there was no planned linking between the different aspects of the task (atomistic approach). Even though technological principles were introduced, students had difficulty translating these principles into a holistic multifaceted technological activity. The students generally did not examine existing technology as a strategy to solve their problem. The students' approach did not use systems but focused on the end-product.
>
> (ibid: 93)

Johnson (1994) is also critical of the adoption of linear 'stage models' of general problem solving applied in a number of formats within the teaching of design and technology, in that they are really only appropriate for well-structured 'exercises' completed by 'experts'. There is a danger of pupils simply adopting such an inappropriate approach to 'real-life' contexts and problems which are, by their nature, 'ill-structured'. However, rather than teaching pupils a 'stage model' of problem solving, he proposes explicit problem solving strategies which can actually be taught within technology (in an American context). He considered that, typically, such problem solving strategies tend to be latent in the classroom, with teachers assigning problems in the hope that the pupils will pick up some problem solving skills by working through them. However, this ought not be confused with Doyle's (1983, cited in Frederikson, 1984) notion of direct and indirect instruction where, 'Indirect instruction tends to be used in teaching higher level cognitive processes and is based more on self-discovery of meaning and purpose; teaching involves providing opportunities for students to derive generalisations and procedures for themselves (...) more appropriate after basic knowledge structures and skills have been acquired' (Frederikson, 1984: 392). Johnson (1994) presents a list of strategies derived from those identified in problem solving research literature, which ought to serve as a focus for 'problem solving instruction' within technology:

- To become competent problem solvers, students should gain the ability to:
  - Identify both given and needed information.
  - Obtain problem information via the senses.
  - Obtain relevant information from technical manuals and other resources.
  - Use technical devices to collect problem information.
  - Create a simplified problem space.
  - Create models to simplify the problem by using diagrams, tables, charts, graphs.
  - Develop a mental image of the problem.
  - Use analogies/metaphors to look at the problem from different angles.
  - Plan before taking action.
  - Recognise patterns.
  - Reason hypothetically.
  - Estimate.
  - Apply rules or formulas.
  - Utilise various search methods such as trial & error, systematic, exhaustive, topographic, split/half.
  - Solve a simpler problem.
  - Work backwards.

- Utilise metacognitive skills such as planning, predicting, evaluating, reflecting.

(Johnson, 1994: 27 & 28)

Rather than emphasise theoretical knowledge associated with problem solving, it is suggested that we should adopt a more reflective but pragmatic approach as teachers, where we consider what Johnson describes as, '*nice to know* rather than *must know* content' (ibid: 29), in conjunction with metacognitive processes such as exposing the hidden processes by drawing them out of the pupils through general 'think aloud' strategies (Glass, 1991, cited in Johnson, 1994) and through specifically getting them to articulate their goals and verbalise their plans for solving problems (ibid). Such an approach is reinforced by Frederikson's assertion that, 'Since most of the research on problem solving has been based on well-structured problems and on structured problems requiring productive thinking, the processes involved in solving ill-structured problems cannot be described with much confidence' (Frederikson, 1984: 392). However it is suggested that:

> Methods of instruction in solving ill-structured problems might include demonstrations, examples, models of good responses, and practise with feedback; but not much is really known about what to demonstrate or what should be practised. It would seem that the examples, models, and practise problems used for teaching should vary more widely than for well-structured problems with respect to format, content and settings. Feedback would be important, since in the present state of our knowledge we probably have to rely on learning by discovery. Perhaps much of what is learned will be tacit. Teachers should not lose sight of the need for students to learn to evaluate their own solutions using methods that to the extent possible are as rigorous as those employed in solving well-structured problems.
>
> (ibid: 394)

It follows that a (greater) sense of understanding of technological principles and processes is needed within problems of an authentic, plausible nature. It is suggested that within such a framework there is more likelihood of innovation via the asking of questions, collecting of information, exploration of a number of ideas and the consideration of such principles and processes in the development of appropriate solutions.

> McCormick et al. (1993) also highlight that it is important to deal with processes explicitly, otherwise students are dealing with apparently isolated tasks. A lack of understanding of the overall process means that students undertake the parts in isolation or follow the design process as a ritual (McCormick, 1997). Students do not necessarily see the relationship between the different stages or problems of the task. Guidance must be given about how to evaluate; learning in technology does not happen by discovery. When technical skills are taught in isolation from the tasks to which they are to be applied, students have problems with transferring them to solve technological problems (Anning, 1994; Jones & Carr, 1993). Transfer needs to be taught directly in technological practice (Johnson, 1997).
>
> (Jones, 1997: 93)

Such consideration leads to questioning of the balance between 'process' and 'product' within design and technology. While it is recognised that an understanding of a 'problem solving model' helps pupils, this should not be at the expense of attention to the content involved, as such neglect will lead to difficulty of transferring learning to other situations (Thomas & Litowitz, 1986, cited in McCade, 1990). 'In such situations, students can be taught to solve problems without becoming problem solvers' (McCade, 1990:31). This links to the notion that design and technology, '...is (we say) a problem-based activity (which is not to say that it is a problem-solving activity)' (Roberts, 1993, cited in Roberts and Norman, 1999: 125).

In a general pragmatic sense, successful and confident advocates of problem-solving approaches to CDT are typified by the advice provided by Burton (1984) in his capacity as a head of department. He emphasises the importance of the relevance to the individual of problem to be solved and maintains that this can be done in such a way that the teacher remains in control (as opposed to responses typified by, ' "Leave it alone - not worth the trouble - always fails - ends up in chaos" ' (Burton, 1984: 36)). He provides support for the predominant use of the linear design line which he considers to have strength in its logical and systematic character. He also acknowledges the appropriateness, to a lesser degree, of the cyclic design loop. However, he sees two issues as central to the effectiveness of use of either process in terms of teaching:

> - Who makes the child aware of the need or problem and how to identify it? Is it the teacher's responsibility?
>
> - What determines the number of sequences needed to bring about a successful solution?
>
> (ibid: 36)

Burton provides very apt and useful reflections linked to these two issues raised:

> Bearing those questions in mind it becomes very apparent, when I visit schools and departments, that they employ what I would call an "antiseptic" view of problem solving.
>
> Basically I refer to it as the "TCP method" which stands for "Teacher directed problems", "Closed-end problems" and "Pupil-orientated problems". I would suggest that possibly all three are employed to greater or lesser extent in departments.
>
> For example, with first-year pupils I initiate them into the problem-solving approach using a simplified version of the linear process, incorporating simplified terminology. This approach is very much teacher-directed. The problem is given; material constraints, tools and techniques are carefully orchestrated.
>
> However, I must emphasise very strongly that the responses are very individual and unique to the pupil and that no two solutions are the same. Alternatively, one can incorporate the "Closed-end problems" which tend to be used more by departments in the design technological end of the CDT spectrum, where specific components are given in such areas as mechanisms, electronics, structures, pneumatics, and the solutions are nearly always

> predictable, especially when using "constructional kits" which have become very popular with departments.
>
> But I will be at pains to point out that once the basics have been understood using this approach it then lends itself to the third area of "TCP" methods - "Pupil-orientated problems", that is problems deriving from a need or situation peculiar to that individual, in simple terms "personal ideas".
>
> (ibid: 36)

In addition, group work incorporating 'stimulus, discussion, problem' is seen by Burton (1984) as a possible solution to the problem of catering for individual needs within a class of twenty-plus pupils, which in turn links to good problem solving practice advocated in terms of 'peer teaching' and social constructivist theories (...) It is interesting to note his acknowledgement of educational principles which he applies to such an approach, for instance:

> If applying the linear approach to problem solving, remember what Eric Hoyle wrote in his book, The Role of the Teacher, in which he suggests that part of a teacher's function is "to move to the periphery and merely create the right conditions for pupil-orientated activities and self-direction". In creating these situations a teacher can still orchestrate or manage the workshop activities by providing the necessary tools, processes, equipment and materials and steering the pupils without too much over-direction.
>
> (ibid: 36)

Burton portrays an image of a very dynamic interesting teacher who relishes the accommodation of children's contemporary interests and concerns into his teaching. This leads one to wonder which aspects of teaching actually influence its effectiveness, and to what degree. Could it be/include other factors such as: quality of stimulus material; the sense of relevance; perception of ownership by the pupils; positioning of topic along the 'design - technology' parameter; quality of teacher organisation; quality of teacher facilitation of the design process; clear sense of aims in using the design process;

understanding and application of educational principles; enthusiasm for reflection and embracement of change?

Suggested approaches from research can be seen to translate to 'advice' for problem solvers. This might include: redescriptions of situations; counteracting 'functional fixedness'; imposing limits; 'chunking', appropriate to the individual's capacity; organising; grouping; categorising (Segal, Chipman & Glaser, 1985). In addition, ' "tried and tested techniques of reducing complex problems to simple problems" can be taught in classrooms' (Lamb, 1991, cited in Weinstein, 1993: 276). Reference to cognitive science has been utilised in America, with particular interest for technology education including: knowledge structures and mental modes; problem-solving processes; metacognition; skill acquisition; situated cognition, and; transfer of learning (Johnson, 1992 & 1994; Johnson & Thomas, 1992 & 1994) plus particular attention paid in England to: situated cognition, and; cognitive apprenticeship, within the PSTE project (Hennessy, 1993; Hennessy et al., 1993; Hennessy & McCormick, 1994; McCormick, 1994; Murphy, et al. 1995;).

As previously discussed, there is a correlation between notions of creativity and problem solving, particularly in terms of 'ill-structured' problems and problems requiring 'productive thinking'. Therefore, in terms of teaching, such links ought to be considered. Indeed, so-called stage theories originated from the realms of creativity. To be fair, it is also claimed, beyond design and technology education, 'Creativity as such has so far received relatively little attention from cognitive psychologists' (Frederiksen, 1984: 384). Frederikson draws together a list of suggestions for instruction based on creativity research and teaching, which, however, is considered to be different to that derived from cognitive theory:

- Allow time for incubation.
- Suspend judgement (eg, Brainstorming).
- Establish appropriate climates (eg, respect and value ideas).
- Analyse and juxtapose elements (eg, attribute listing).
- Teach the underlying cognitive abilities (eg, underlying abilities from SI model).
- Provide practice with feedback.

(adapted from Frederikson, 1984)

Importantly, within the current context of importance of 'learning and thinking skills and styles':

> In training for problem solving, both for well- and ill-structured problems, it seems wise to be alert for individual differences in problem respresentations and problem-solving procedures, especially differences that are related to aptitudes, and to learn to adapt the instruction to the student's particular skills and abilities rather than requiring that the student adapt to the teaching (Snow, 1982).
>
> (Frederikson, 1984: 394)

Also, a greater level of accountability will enhance the quality of learning (Doyle, 1983, cited in Frederikson, 1984), and, 'The more realistic the settings, the greater the likelihood of generalisation to real-life problems'. Johnson (1997) considers implications for technology education based on the fact, 'that learning will be enhanced when students reflect on and collaborate with others as they solve technological problems that occur in rich contexts' (Johnson, 1997: 175). He further considers that historically behavioural learning theories have been applied to technology education but:

> ...because of the changing nature of the workplace and society, there is an increased need to emphasise learning goals that involve the development of understanding and the improvement of intellectual skills. These types of goals require that instruction be designed around the social-contructivist learning theories. This will result in the design of stimulating learning environments in which flexible, highly active, group and project-orientated methods are used.
>
> (ibid: 177-178)

Suggested starting points for such an approach are based on elements of 'informal learning' as opposed to 'formal learning' and instructional principles and strategies for enhancing cognitive learning[5].

In the context of 'cognitive matching', problem solving is a higher level thinking skill involving 'abstract learning' allied to analysis, synthesis and evaluation (Bloom's cognitive domain taxonomy (1956)), and, as such, cannot occur without appropriate 'concrete learning' allied to knowledge, understanding and application (McCade, 1990). Therefore, the implications for teaching must touch on 'concrete' and 'abstract' learning, linked to divergent thinking and the current curriculum emphasis on convergent thinking (ibid) plus consideration of levels of operation by individual pupils in terms of working independently or with the aid of 'support' provided by the teacher (Bruner, 1977; Cole, et.al., 1978; Smith & Cowie, 1991; Feuerstein, et al., 1981; Glover, Ronning & Bruning, 1990). Anderson (1989) utilises a conscious use of Bloom's taxonomy within the context of a cognitive model designed to enable teachers to design a curriculum and select appropriate corresponding teaching methodologies. This potentially takes teachers

[5] Refer to Johnson (1997) pages 168-169 and page 176 for further details.

beyond existing patterns of teaching. Within such a hierarchical model of learning, the teacher should focus on the students' knowledge of the steps and ensure that they can apply them to different problem situations. It is further maintained that problem solving requires the pupils to be guided by the teacher in order that they become able to function in all six levels of Bloom's taxonomy. However, it is pointed out that they need to go beyond simply being able to recall such a model as it is based on a cognitive process. Links are made to research carried out by Heiman & Slomianko (1985) in the identification of successful teaching methods for helping students become proficient in problem solving:

- Have students think aloud
- Reinforce a systematic process
- Have students work in pairs or small groups
- Have students generate possible solutions using ideation strategies
- Reinforce questioning behaviour by positive responses
- Provide situations for transfer of learned problem-solving skills
- Use repetition to reinforce and practise problem-solving skills.

(adapted from Heiman & Slomianko, 1985: 10-11)

Perhaps it is simply the case that, ultimately, teachers 'should remember that students learn to solve problems by actually solving them...' (Teare, 1980: 166) analogous to people learning to ride bicycles, mostly by riding them, as opposed to having the theory explained. Also, instructional implications of research into problem solving indicate that even if general, or indeed specific, problem solving skills exist, it might not be possible to teach them in a direct way, and that they need to emerge in a spontaneous way as a consequence of appropriately planned experiences (Segal, Chipman & Glaser, 1985). However, such pedagogical consideration is complicated by the fact that, 'It is generally agreed that learning should be directed toward problem solving, but there is no widely accepted plan for teaching general problem-solving skills' (Teare, 1980: 163).

Various issues associated with teaching and learning beyond the design and technology community have been raised, which, it is maintained, ought to be applied within the teaching and learning of the subject to a greater extent, as:

> ...the development of higher cognitive skills that enable students to be independent learners and independent, creative problem solving users of their knowledge has always been a very important goal for educators. There is evidence, however, that explicit instruction in these skills is rare and that students' mastery of them is frequently inadequate.
>
> (Chipman & Segal, 1985: 5)

Summary

A review of the literature shows a desire for greater inclusion of problem solving within the curriculum as a whole and, to varying extents, design and technology. Throughout such development there has been a recognised need for problem-solving skills to develop in order that individuals might transfer such ability to novel situations in autonomous ways. Such a desire implies greater emphasis on 'process' rather than 'product' - i.e., that which an individual can *do* and *apply* is more important than what they might *know*.

The following was discussed in this chapter: (a) the historical development of design and technology with a focus on problem solving, (b) change in society linked to the need for problem solvers, (c) more recent curriculum development in terms of National Curriculum Technology / Design and Technology, and (d) pedagogical issues associated with teaching and learning of problem solving.

Problem solving has often been confused with designing within school subject of design and technology. Such confusion is linked to the acceptance and dominance of the design process as a staged-model approach to the teaching and learning of design and technology. Design and technology has often been promoted on the basis of pupils starting from a design brief (often given) and utilisation of a/the design process to 'develop' and manufacture a 'solution'. It is argued from pedagogical perspectives that such an approach falls short of problem-solving requirements as there is a need for greater understanding of processes involved and that problem solving might need to be 'taught', as opposed to simply 'experienced'. However, there is recognition of conflict and tension between designing and problem solving in response to open-ended design-based problems and manufacturing well-made products.

Chapter 3 Methodology

Methodological Considerations

It can be demonstrated that pedagogical considerations within the teaching and learning of design and technology are central to our understanding of any judgments made about its effectiveness. It is important to gain insight into desires, aspirations and concerns of those involved as well as actualities. The empirical stage of the research therefore involved gaining insights into the perceptions and experiences of practitioners within the field of design and technology. It was approached so that the previous focus on the development of the subject in terms of an emphasis on problem solving could be contextualised. Many issues associated within the review of general literature as well as more direct curriculum documentation, have been reviewed and it is important now to establish the reality in terms of teaching and learning of the subject occurring in secondary schools at key stage 3.

The essentially practical, problem solving subject matter of this research lends itself to a consideration of the researcher as a practitioner who has identified a problem during the course of involvement and work in the 'field', sees the merit of investigating it and, if possible, of contributing to improving practice. As such, it can be described as 'action research'. Action research has been popular as a method of research in education and has been described as designed to enhance the quality of action and advance practice (Bassey, 1990b).

The research is concerned with those who are directly involved in the teaching and learning of design and technology, that is, design and technology practitioners and pupils. As such, it is grounded in school and classroom practice and depends on 'criticism' as a means of testing the validity of findings in the absence of an established theoretical background (Bassey, 1990b). It is reassuring to discover that the concept of the 'critical friend' (Bassey, 1990b) has been developed within the desired model of the reflective practitioner' (Schon, 1983).

The desire for data associated with the 'reality' of practice led to the question of who might be deemed as appropriate 'practitioners' within the teaching and learning context of design and technology (from a problem solving perspective). An obvious first choice was design and technology departments and groups of key stage 3 pupils. However, the experiences of teachers and pupils occur within a framework established in part by 'experts', 'educators' and 'trainers' within the field of design and technology education. It follows that local and national individuals and natural groups needed special consideration. The original intention was to involve Local Education Authority advisers and inspectors who covered the range of schools involved, as well as Her Majesty's Inspectorate, teacher trainers and curriculum project leaders (who would also have experience within associated areas of research). Representation of all of these perspectives was facilitated through the involvement of two further groups termed as 'experts', with the exception of Her Majesty's Inspectorate who had to decline such an offer of involvement due to official guidance.

Use of such multiple sources of data within a case-study approach ameliorates difficulties over reliability and personal bias, as well as enabling greater potential for generalisation of results (Anderson, 1990). The major safeguard on validity associated with the use of data from a range of sources, 'is referred to as triangulation, whereby various sources of data point in the same direction relative to a given solution' (ibid: 175).

To obtain data from 'practitioners', group interviewing was chosen ahead of observation due to the desire for personal involvement of a large range of individuals involved, allied to an existing depth of experience of observation through my role as a lecturer involved in teacher training. Also, it seemed that direct access to a wider cross-section of those involved would lead to a more productive correlation between the 'official' development of the subject and the 'reality' of experience. Such an approach, as opposed to the use of questionnaires, would ensure data of a qualitative nature based on relevant issues being raised by groups of practitioners. Supporters of qualitative research claim that such 'probing' for most truthful responses can yield a more in-depth analysis than that produced by formal quantitative methods (Mariampolski, 1984). With this in mind, it was anticipated that access to a broad range of schools would be possible within a geographical area convenient to existing demands of employment. Within this area it would be possible to access 'inner-city' as well as 'leafy suburb' schools ranging between single- and mixed-sex compositions. As such, the research provides an opportunity to gather data and seek emerging patterns (Maykut & Morehouse, 1994).

Scale of Enquiry

Sufficient range, spread and balance was achieved through the use of twelve secondary school departments. It was also envisaged that useful data would emanate from a corresponding group of design and technology advisers and inspectors for this geographical area as well as any national figures associated with the development of the subject.

Limitations of the Methodology

The qualitative nature of the research might be seen by some to lack a 'scientific' approach and rigour, however, such research is 'highly data based and strives for the same degree of reliability as any good research' (Anderson, 1990: 157). Limitations of the research relate to concepts of validity and generalisation within the sample of schools and the context of the two 'expert' groups. Internal validity is endeavoured through confidence in results obtained being true for those participating in the study (ibid). Although external validity is rightly judged as a prerequisite for actual generalisability it is argued that potential generalisability is achieved through multiplicity of case-studies and sources of data (ibid).

Truly objective research is difficult to obtain, however, acceptance of research reflecting the values, beliefs and perspectives of the researcher does not mean that such research is subjective (ibid). Furthermore, a 'perspectival' approach is considered more appropriate in defending and justifying qualitative research than argument over objective and subjective constructs (Maykut & Morehouse, 1994). 'Perspectival has the added advantage of being inclusive of differing perspectives, including but not limited to the researchers' perspective' (ibid: 20).

Method of Research and Analysis

Central to the research are the perceptions of those involved in problem solving within design and technology. Although broad concern over the effectiveness of problem solving have been declared/expressed by the researcher, it was important to avoid the use of preconceived opinion. As such, qualitative research was selected based on a 'naturalistic enquiry' approach (Lincoln & Guba, 1985, cited in Robson, 1993) within school departments as 'natural settings'. Reasons for such an approach included the desire for issues to emerge from within the broader context of the perceptions of pupils, teachers and 'experts'. 'Grounded theory' would subsequently emerge from the data collected and analysed inductively. The involvement of tacit knowledge of those involved encourages 'generalisation' of results (ibid), and, as such, it is accepted that both inductive and deductive processes are involved (Scott & Usher, 1999). Central to this was the need for objective opinion which could be analysed for genuine concerns. This approach lends itself to being able to analyse perceptions and experiences. Establishment of grounded theory is based on the following set of procedures:

Process	Activity	Comments
i.	Collect data	Any source of textual data may be used but semi-structured interviews or observations are the most common
ii.	Transcribe data	It is necessary to produce full-transcriptions of the data in order to analyse them
iii.	Develop categories	Categories are developed from the data by open coding of the data
iv.	Saturate categories	Further examples are gathered as one proceeds through the transcripts until no new examples of a particular category emerge
v.	Abstract definitions	Once the categories have been saturated, formal definitions in terms of the properties and dimensions of each category may be generated
vi.	Theoretical sampling	From the categories which have emerged from the first sample of data, relevant samples are theoretically chosen to help test and develop categories further
vii.	Axial coding	Using the method of axial coding, possible relationships between categories are noted, and hypotheses are actually tested against the data obtained in ongoing theoretical sampling
viii.	Theoretical integration	A core category is identified and related to all the other subsidiary categories by means of coding, and links with established theory are made
ix.	Grounding theory	The emergent theory is grounded by returning to the data and validating it against actual segments of the text
x.	Filling the gaps	Finally, any missing detail is filled in by further collection of relevant data

Table 1. Grounded Theory (Bartlett and Payne, 1997, cited in Scott & Usher, 1999: 42).

To accommodate such needs 'focus group' interviews were chosen as they enable perceptions to emerge from planned discussion in a permissive non-threatening environment (Krueger, 1988). The open-ended approach of focus groups allows those involved ample opportunity to comment, explain, and to share experiences and attitudes - as opposed to the more structured directive interviews dominated by an interviewer (ibid). Also, there is the additional advantage of them acting as, 'part of a larger effort to "triangulate" different forms of data collection on the same topic' (Denzin, 1978;

Fielding & Fielding, 1986; cited in Morgan, 1988). Their independent, self-contained nature is also a crucial feature of their ability to contribute to triangulation (Morgan, 1988: 25). Although originally intended for individuals unfamiliar with each other, other design factors lend themselves to this research and the participants involved:

> Focus groups produce qualitative data that provide insights into the attitudes, perceptions, and opinions of participants. These results are solicited through open-ended questions where respondents are able to choose the manner in which they respond and also from observations of those respondents in a group discussion. The focus group presents a natural environment where participants are influencing and influenced by others - just as they do in real life. The researcher serves several functions in the focus group: moderating, listening, observing, and eventually analysing using an inductive process. The inductive researcher derives understanding based on the discussion as opposed to testing or confirming a preconceived hypothesis or theory.
>
> (Krueger, 1988: 30)

To facilitate both the concept of 'triangulation' within the research as well as 'generalisation' of results, issues associated with the range of participants had to be considered. It was important to identify trends and patterns of perceptions within teaching and learning of design and technology and therefore a range of schools were selected within a geographical area convenient to the researcher. To get a balance of types of schools within the state sector a variety of single-sex and mixed-sex schools were selected within both 'leafy-suburb' and 'inner-city' environments across the north London and south Hertfordshire area. As issues associated with both teaching and learning of problem solving in design and technology were central to the research, focus group interviews were devised for groups of teachers and corresponding groups of pupils. The composition of the teacher groups were to be based on departmental organisation. This varies between craft design and technology (CDT) departments and technology faculties including teachers of 'specialisms' such as textiles, food technology and information technology (IT).

Guidance provided by Krueger (1988) was utilised in the development of the focus groups which were planned to last for approximately thirty to forty minutes. The 'questioning routes' were designed as focused sequences in a convergent manner, based overall on open-ended questions but with greater focus facilitated by a gradual shift towards closed-ended questions. Therefore, a logical sequence was to be presented to the participants, beginning with general overview questions funnelling into more specific questions of critical interest. Each question would be supported by potential 'probes', to be used when it was deemed necessary to provide a greater degree of focus or clarification. Great care was taken over the use of language within the questions to allow respondents to maintain 'ownership' of responses. An attempt was made to avoid overuse of 'dichotomous' questions which could simply be answered with a simple "yes" or "no" response. Also, questions prefixed by "why" were avoided as they imply a sharpness or 'pointedness' which could inculcate defensive barriers and socially acceptable responses to controversial issues.

Initially, the focus of 'questioning route' design was based on the sessions to be conducted with groups of teachers, with subsequent minor amendments made for the equivalent questions to be asked of the other groups of pupils and experts. Combined consideration of reflection on the previous literature search and design considerations indicated by experienced researchers led to the following set of questions and supportive probes:

FOCUS GROUP INTERVIEW - TEACHERS

'Questioning Route' and possible 'Probes'

Question 1: What do you think about problem solving in design and technology at key stage 3 in terms of it's educational merit and value?

Probe: What do you think about it's validity ? - is it worthwhile?

Question 2: How do you feel about teaching which involves problem solving in design and technology at key stage 3?

Probe: What is most problematic about it?

Question 3: How do you think the pupils feel about being involved in problem solving in design and technology at key stage 3?

Probe: Do you think they enjoy it or find it difficult?

Question 4: What do you think about the characteristics of problem solving?

Probe: Do you think there are different types of problem solving? - a hierarchy?

Question 5: How do you allow for progression and differentiation when teaching design and technology involving problem solving?

Probe: Do you consider aspects of open-endedness and prescribed tasks, or familiar and unfamiliar contexts?

Question 6: Do you feel that you actually teach problem solving?

Probe: Do you teach them how to go about a process of problem solving - within a framework - involving thinking skills?

Question 7: Do you have access to any information about teaching involving problem solving?

Probe: From your original training, previous experience, INSET, etc.?

Question 8: What do you think about the relationship between 'problem solving', 'creativity' and 'designing' in design and technology?

Probe: Are they closely linked (one-of-the-same) or very distinct? Do you think they get confused?

Table 2. Questioning Route for Teachers.

A corresponding version for use with pupils was:

FOCUS GROUP INTERVIEW - PUPILS

'Questioning Route' and possible 'Probes'

<u>Question 1</u>: **What do you think about problem solving in design and technology?**

<u>Probes</u>: Do you think it is a good part of design and technology?
Do you enjoy it or dislike it
Is it worthwhile or a waste of time?
Do you find it easy or difficult?
What do you think is the most easy and difficult parts of problem solving in design and technology?

<u>Question 2</u>: **Can you give me an example of problem solving in design and technology?**

<u>Probes</u>: The most recent project involving problem solving?
What project are you working on at the moment in design and technology - are you 'problem solving' in this project?

<u>Question 3</u>: **Do you do problem solving in any other subject(s) in school?**

<u>Probe</u>: Is it different in any way?

<u>Question 4</u>: **Do you think there are different types of problem solving?**

<u>Probe</u>: What is special about problem solving in design and technology?

<u>Question 5</u>: **How do problems get harder to solve?**

<u>Probes</u>: How do teachers make problems easier or harder to solve?
What about open-ended or fixed problems?
What about familiar and unfamiliar problems (contexts)?

<u>Question 6</u>: **Do you think the teachers actually teach you how to solve problems in design and technology?**

<u>Probe</u>: In what way do they help you solve the problems set in design and technology?

<u>Question 7</u>: **Why do you think you do problem solving in design and technology?**

<u>Probe</u>: For what reason / which reasons?

Table 3. Questioning Route for Pupils.

The following version was devised for the two groups of experts:

FOCUS GROUP INTERVIEW - 'EXPERTS'

'Questioning Route' and possible 'Probes'

Question 1: **What do you think about problem solving in design and technology at key stage 3 in terms of it's educational merit and value?**

Probe: What do you think about it's validity ? - is it worthwhile? - is it successful?

Question 2: **How do you feel about teaching which involves problem solving in design and technology at key stage 3?**

Probes: What seems to be most problematic about it?
How do you think the student teachers and teachers feel about being involved in teaching D&T involving problem solving?

Question 3: **How do you think the pupils feel about being involved in problem solving in design and technology at key stage 3?**

Probe: Do you think they enjoy it or find it difficult?

Question 4: **What do you think about the characteristics of problem solving?**

Probe: Do you think there are different types of problem solving? - a hierarchy?

Question 5: **How should teachers allow for progression and differentiation when teaching design and technology involving problem solving?**

Probe: Do they consider aspects of open-endedness and prescribed tasks, or familiar and unfamiliar contexts?

Question 6: **Do you feel that the teachers actually teach problem solving?**

Probe: Do they teach them how to go about a process of problem solving - within a framework - involving thinking skills?

Question 7: **Do the teachers have access to any information about teaching involving problem solving?**

Probes: From their original training, previous experience, INSET, etc.?
Do you offer any INSET based on problem solving?
Do you think it would be useful to offer INSET based on problem solving?

Question 8: **What do you think about the relationship between 'problem solving', 'creativity' and 'designing' in design and technology?**

Probe: Are they closely linked (one-of-the-same) or very distinct? Do you think they get confused?

Table 4. Questioning Route for 'Experts'.

The analysis of the data from the focus groups would represent 'the final stage of listening to hear the meaning of what is said' (Rubin and Rubin, 1995: 226). It was important to retain a genuine sense of enquiry within the context of the focus of the research. There is always a danger of hearing what we want to hear as opposed to what was actually said. It must therefore be emphasised that the intention was to enable the issues to emerge from the data which had been gathered and assembled (ibid). The traditional method of data analysis based on the 'scientific' deductive approach was deemed to be inappropriate, as an actual hypothesis had not been generated prior to the beginning of the study - despite the attraction of mathematically analysing the predetermined data variables. Within the context of qualitative research an inductive approach to data analysis was more appropriate where:

> Data are collected that relate to a focus of inquiry. Hypothesis are not generated a priori and thus the relevant variables for data collection are not predetermined. The data are not grouped according to predetermined categories. Rather, what becomes important to analyse emerges from the data itself, out of a process of inductive reasoning.
>
> (Maykut and Morehouse, 1994: 126, 127)

Initial analysis of the focus group data would be based on the approach aligned to qualitative or ethnographic summaries as opposed to a systematic coding leading to numerical descriptions (Morgan, 1988), in spite of the seduction of analysis of numbers (Krueger, 1988). Importance was placed on how one can draw valid and reliable meaning from qualitative data. With this in mind, the computer software package entitled *HyperQual2* was utilised to facilitate qualitative data analysis based on the 'constant comparative method' (Glaser and Strauss, 1967, cited in Maykut and Morehouse, 1994).

The constant comparative method is an approach firmly rooted within the qualitative data analysis process of 'culling' for meaning from the words (or actions) of the participants in the study, framed by the researcher's focus of inquiry. The initial stage is one of identifying chunks or units of meaning in the data; sometimes referred to as 'unitising' the data (for example, Lincoln and Guba, 1985, cited in Maykut and Morehouse, 1994). These 'chunks' of meaning are coded providing a mechanism for assembling a large array of potentially important experiences, opinions, thoughts and concepts. This process enables the initial act of 'discovery' (Taylor and Bogdan, 1984, cited in Maykut and Morehouse, 1994) to occur where recurring themes are identified. As such:

> The constant comparative method of analysing qualitative data combines inductive category coding with a simultaneous comparison of all units of meaning obtained (Glaser and Strauss, 1967). As each new unit of meaning is selected for analysis, it is compared to all other units of meaning and subsequently grouped (categorised and coded) with similar units of meaning. If there are no similar units of meaning, a new category is formed. In this process there is room for continuous refinement; initial categories are changed, merged, or omitted; new categories are generated; and new relationships can be discovered (Goertz and LeCompte, 1981).
>
> (Maykut and Morehouse, 1994: 134)

This process can be illustrated as:

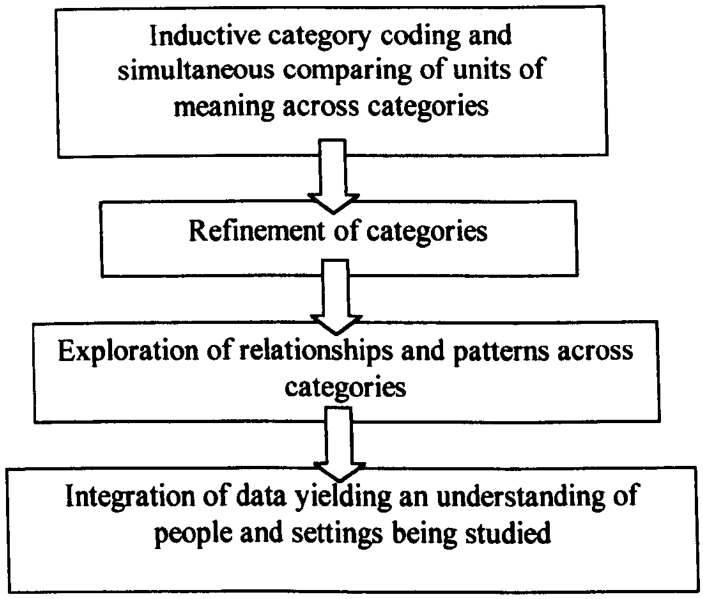

Figure 6. Constant Comparative Method of Analysing Qualitative Data (ibid: 135).

HyperQual2 utilises HyperCard as its 'software engine' and as such it provides a means of being able to perform the 'mechanical' effort associated with qualitative data analysis, enabling the researcher to concentrate more on conceptual aspects. 'Mechanical' tasks include the acquisition of data, the recording and storage of the data, the manipulation of chunks of data, and the preparation for reporting findings and conclusions of the investigation. The conceptual aspects include the identification of meaningful chunks of data, the development of concepts or categories to organise these chunks, and the discovery of meaningful patterns of concepts so that 'theory construction' can occur and the situation under study can be understood within the framework of the investigation.

Researchers such as Tesch have advocated and developed the use of computers in grouping coded data as they recognise that 'it is fast and efficient and saves many, many hours of tedious work' (Tesch, 1990, cited in Rubin and Rubin, 1995: 241). However, it should be noted that such acknowledgement and promotion should be tempered with a warning that (currently):

> ...the computer cannot do the creative part of coding, such as setting up and modifying the categories and figuring out in what categories each segment of an interview belongs. Nor can the computer label ideas as concepts or recognise themes, compare the separate concepts, find subtleties in meaning, or follow up on comparisons and nuances. Computers can take much of the drudgery out of coding a large data set, but any claims for a computer software package that it can think for you are exaggerated.
>
> (Rubin and Rubin, 1995: 241)

Summary

This chapter presented the methodology for the study. The design of this study was based on qualitative research. Such an approach was selected on the basis of seeking emergent themes and issues from those experiencing, observing and influencing learning and teaching of design and technology within an 'opportunity sample'. The use of qualitative research was defended in terms of validity and is considered as providing a 'perspectival' view on issues associated with the research focus. Focus group interviewing was selected as the source of data required for analysis. Data gathering was carefully considered through the design of appropriate focus group questioning routes. Validity was enhanced through multiplicity of data provided through the range of schools utilised and involvement of participants considering and commenting on problem solving from different perspectives. The 'constant comparative method' of data analysis was adopted to facilitate consideration of emergent themes.

Chapter 4 Implementation

Use of data emanating from focus group interviewing was central to the next phase of the research. This approach was conducted with groups of teachers, pupils and 'experts' within design and technology education.

'Handshaking' With Schools

Schools were approached around the north London area, in line with the proposed sample. In the majority of cases contact was made via the telephone. In all cases the researcher was a known figure to the school; therefore, arrangements were based on an existing formal or informal professional relationship with the researcher's area in the university. A brief introduction to the nature of the research was provided at this stage in an attempt to supply sufficient information to busy teachers while minimising the potential for prejudgments to be formed (on either side). In addition an explanatory letter was provided for those involved in the setting up of the meetings; usually a head of department or faculty (see appendix F). All interviews were conducted at the respective schools.

As indicated above, a balance was achieved through the choice of 'types' of schools. This was based on an 'opportunity-sample' of 'state schools' around north London; half 'inner-city' and half 'leafy-suburb'. However, there was in fact a useful mix between types of schools and intakes within both categories. Of the inner-city type schools: two were mixed gender; two were girls' schools; and two were boys' schools. Of the leafy-suburb type schools: two were mixed gender; two were girls' schools; and two were boys' schools.

The schools were visited over a period of 21 months, between May 1994 and November 1996. Some were visited twice, as it was necessary to conduct the interviews on different days with the pupils and staff. Others were visited once since it was possible to conduct both interviews on the same day. The length of time between starting and completing the focus group sessions was due mainly to the difficulties associated with the researcher's full-time teaching commitments, the teachers' busy schedules, and practicalities over seeking and arranging mutually convenient occasions. During this time factors arose having a bearing on possible perceptions about the nature of national curriculum design and technology within England.

It is worth recalling at this stage way the subject of design and technology emerged during this period of time - influencing the perceptions of teachers in the schools. A national curriculum foundation subject entitled 'technology' was originally established for all children in state schools in England and Wales between the ages of five to sixteen in 1990. Difficulties were encountered over the terminology adopted - especially the confusion of the relative meanings of technology and design and technology. The subject title of 'technology' had to be maintained due to the original legislation. Technically, the subject included 'design and technology' and 'information technology', with design and technology encompassing craft, design and technology (CDT), home economics and business studies (as well as aspects of art and design).

Technology was made up of five attainment targets, four of which were attributed to design and technology with the remaining one being information technology. The four attainment targets for design and technology were:

> *Attainment target 1: Identifying needs and opportunities.*
> Pupils should be able to identify and state clearly needs and opportunities for design and technological activities through investigation of the contexts of home, school, recreation, community, business and industry.
>
> *Attainment target 2: Generating a design.*
> Pupils should be able to generate a design specification, explore ideas to produce a design proposal and develop it into a realistic, appropriate and achievable design.
>
> *Attainment target 3: Planning and making.*
> Pupils should be able to make artefacts, systems and environments, preparing and working to a plan and identifying, managing and using appropriate resources, including knowledge and processes.
>
> *Attainment target 4: Evaluating.*
> Pupils should be able to develop, communicate and act upon an evaluation of the processes, products and effects of their design and technological activities and of those of others, including those from other times and cultures.
>
> (Department of Education and Science and the Welsh Office, 1990: 3, 7, 11 & 15)

The original intention was to create an approach to learning based on problem solving through designing and making, and in many ways this was considered to be a forward-looking 'liberal' strategy. There were many difficulties encountered by practitioners who often considered it to be an unworkable model, particularly in relation to the ability of pupils and teachers to operationalise attainment target 1. Numerous revisions were made to the original version which culminated in a further design and technology Order in 1995 setting out the framework for the duration of a promised five-year period without any substantial change. The four attainment targets were simplified to two, which were:

Attainment target 1: Designing.

Attainment target 2: Making.

Despite all these developments the analysis of data in this study was such that the changes to the national curriculum did not detract from the fundamental questions. In other words, most of the underlying issues and concerns involved fundamental pedagogical principles and aspirations that could be distinguished from specific reactions to the national curriculum.

Contextual Descriptions of the Schools and Teachers Involved

Portrayal of the type and performance of the schools can be gleaned from relevant *Ofsted* (Office for Standards in Education) reports. The period of research coincided with an intensive period of inspection of schools through the establishment of a new rigorous regime. The *Ofsted* inspections took place close to the times of the focus group sessions; some before and some after. When the factors associated with the process of change in schools (Hargreaves, 1994; Fullan, 1992) are considered it becomes clear that schools take time to alter in any significant way and within this context it seemed justifiable to use the inspectors' findings as a basis for providing an objective 'snapshot'. *Ofsted* reports were downloaded from the Internet and information from relevant sections covering the introduction, main findings and what the school should do now, standards and quality pupils' personal development and behaviour, as well as the section on design and technology were used. A summary of the nature and types of schools used are shown in table 5. Detailed descriptions can be seen in appendix G.

School	Roll	'Type'	Gender	Ages	6^{th} Form	% Free Meals	'*Ofsted* & additional Factors'
1	830	Inner-city comprehensive	Girls	11-19	+Boys	'Average'	Good *Ofsted* result. Positively diverse.
2	1275	Inner-city comprehensive	Mixed	11-19	Yes	'High'	Quite good *Ofsted* result. High percentage of special needs pupils.
3	1000	Inner-city comprehensive	Boys	11-19	Yes	'Very High'	Weak *Ofsted* result. High proportion with English as an additional language, etc.
4	1200	Inner-city comprehensive	Girls	11-19	+Boys	'High'	Quite good *Ofsted* result. Popular over-subscribed school.
5	600	Leafy-suburb grant maintained comprehensive	Mixed	11-19	Yes	'Average'	Quite good *Ofsted* result. Some years have high proportion of special needs pupils. Positive learning environment.
6	950	Leafy-suburb comprehensive	Girls	11-19	Yes	'Very low'	Very good *Ofsted* result. Very few low achieving pupils. Affluent setting.
7	1100	Leafy-suburb grant maintained comprehensive	Boys	11-19	Yes	'Negligible'	Very good *Ofsted* result. Operates within grammar / independent school ethos with entrance tests.
8	800	Inner-city comprehensive	Mixed	11-19	Yes	'Very high'	Weak *Ofsted* result. Lots of pupils leaving and joining. High proportion with English as an additional language.
9	760	Leafy-suburb comprehensive	Boys	11-19	Yes	'Very low'	Quite good *Ofsted* result. Above average intake for the wider area.
10	1000	Leafy-suburb comprehensive	Girls	11-19	Yes	'Very low'	Very good *Ofsted* result. Intake covers whole ability range, but with a bias towards the more able.
11	900	Leafy-suburb comprehensive	Mixed	11-19	Yes	'Average'	Quite good *Ofsted* result. Below average intake for the wider area.
12	750	Inner-city comprehensive	Boys	11-19	+Girls	'High'	Quite good *Ofsted* result. Quite high proportion of special needs pupils.

Table 5. Characteristics of Schools within the Sample.

Teachers involved in the focus group sessions were asked to provide details about themselves, through the initial completion of pro formas (appendix H), in order that emergent patterns between responses and factors such as age, gender, types of training and experience might be established. Responses to the questions asked on the forms highlighted some of the difficulties associated with the definition, interpretation and understanding associated with national curriculum developments, including the very meaning of design and technology. Rather than imposing the viewpoint of the researcher, it was considered to be appropriate to let the schools effectively determine their own representation of the different areas within design and technology. Some schools operated on the basis of a design and technology department as a coherent body of people with expertise ranging from food and textiles to craft, design and technology (CDT) or resistant materials; while others limit representation to CDT or resistant materials, with food and textiles effectively existing as a different department elsewhere in the school. Also, eleven out of the twelve heads of departments or faculties in the featured schools had a personal CDT or resistant materials bias (the only exception being a textiles specialist in school 8). This is probably representative of the national picture as far as positions of responsibility are concerned. The following chart (tables 6 to 17) indicates the 'types' of design and technology as represented within the various schools. Detailed description can be seen within appendix G.

Teacher	Sex	Status	'Type'	Age	Yrs	Entry Qual.	ITT Subject	Previous Degree
1	M	H.O.D.	CDT	33	7	2-Yr PGCE	D&T	Economics
2	F		CDT	28	3	2-Yr PGCE	D&T	Art/Art History
3	F		CDT	29	1	PGCE	A&D	Interior Design

Table 6. School 1 Department Characteristics.

Teacher	Sex	Status	'Type'	Age	Yrs	Entry Qual.	ITT Subject	Previous Degree
1	M		CDT	38	17	Cert.Ed	(Geog)-D&T	
2	F		CDT	32	4	PGCE	D&T	Jewellery Design
3	F		CDT	32	4	PGCE	D&T	Theatre Design
4	M		CDT	35	1	PGCE	D&T	Theatre Design

Table 7. School 2 Department Characteristics.

Teacher	Sex	Status	'Type'	Age	Yrs	Entry Qual.	ITT Subject	Previous Degree
1	M	H.O.D.	CDT	32	8	B.Ed	D&T	
2	F	2 i.c.	CDT	36	4	2-Yr PGCE	D&T	Fashion & Textiles
3	M		CDT	26	1	PGCE	D&T	Electronic Engineering

Table 8. School 3 Department Characteristics.

Teacher	Sex	Status	'Type'	Age	Yrs	Entry Qual.	ITT Subject	Previous Degree
1	F	H.O.D.	CDT	36	15	B.Ed	D&T/A&D	
2	F		Text.	42	21	Cert.Ed	Textiles	
3	F		CDT	37	4	PGCE	D&T	Textiles
4	M		CDT	29	2	PGCE	D&T	Design/Manag't
5	F		CDT	33	1	PGCE	D&T	3D Ceramics Design
6	M		CDT	29	1	PGCE	D&T	Interior Design
7	F		CDT	28	0	PGCE student	D&T	Materials Science / Eng'g Marketing

Table 9. School 4 Department Characteristics.

Teacher	Sex	Status	'Type'	Age	Yrs	Entry Qual.	ITT Subject	Previous Degree
1	M	H.O.D.	CDT	42	20	Cert.Ed	CDT	
2	F		Food	44	14	Teach.Cert	Dom. Science	
3	M		IT	43	20	PGCE	Int. Science	Zoolology
4	M		CDT	37	14	Cert.Ed	CDT	
5	F		Text.	50	28	Teach.Cert	Dom. Science	
6	F		D&T	22	0	B.Ed student	D&T	

Table 10. School 5 Department Characteristics.

Teacher	Sex	Status	'Type'	Age	Yrs	Entry Qual.	ITT Subject	Previous Degree
1	M	H.O.D.	CDT	31	9	B.Ed	D&T	
2	F		Text.	34	3	2-Yr PGCE	D&T	Clothing Design /Tech.
3	F		Food	27	3	B.Ed	D&T	
4	F		CDT	29	1	PGCE	D&T	3D Design
5	M		CDT	37	3	PGCE	D&T	Botany

Table 11. School 6 Department Characteristics.

Teacher	Sex	Status	'Type'	Age	Yrs	Entry Qual.	ITT Subject	Previous Degree
1	M	H.O.D.	CDT	40	13	PGCE	D&T	Architecture
2	M		CDT	38	17	Cert.Ed	CDT	
3	M		CDT	44	4	B.Ed	D&T	
4	M		CDT	49	0	B.Ed student	D&T	

Table 12. School 7 Department Characteristics.

Teacher	Sex	Status	'Type'	Age	Yrs	Entry Qual.	ITT Subject	Previous Degree
1	F	H.O.D.	Text.	33	10	PGCE	D&T	Creative Arts
2	F	2 i.c.	CDT	31	7	PGCE	D&T	Civil Engineering
3	F		Food	29	7	PGCE	D&T	Home Economics
4	F		CDT	30	2	PGCE	D&T	Silversmithing
5	F		CDT	29	1	PGCE	D&T	3D Design

Table 13. School 8 Department Characteristics.

Teacher	Sex	Status	'Type'	Age	Yrs	Entry Qual.	ITT Subject	Previous Degree
1	M	H.O.D.	CDT	49	28	Cert.Ed	CDT	
2	M		CDT	50	28	Cert.Ed	CDT	
3	M		CDT	30	6	PGCE	D&T	3D Design
4	M		CDT	29	1	PGCE	D&T	Industrial Design

Table 14. School 9 Department Characteristics.

Teacher	Sex	Status	'Type'	Age	Yrs	Entry Qual.	ITT Subject	Previous Degree
1	F	H.O.D.	CDT	40	18	PGCE	Physics	Physics
2	M		CDT	45	15	PGCE	Science	Biology
3	F		F&T	41	21	Cert.Ed	Dom. Science	
4	F		Text.	37	15	Cert.Ed	Art-D&T	
5	F		IT	44	9	Cert.Ed	Physics/Elec.	

Table 15. School 10 Department Characteristics.

Teacher	Sex	Status	'Type'	Age	Yrs	Entry Qual.	ITT Subject	Previous Degree
1	M	H.O.D.	CDT	44	22	B.Ed	D&T	
2	M		CDT	42	14	B.Ed	History/D&T	
3	F		CDT	44	22	Cert.Ed	D&T	
4	F		CDT	46	24	B.Ed	History-D&T	
5	F		CDT	41	5	PGCE	D&T	Architecture
6	F		F&T	40	3	B.Ed	Food & Text.	
7	M		CDT	32	1	PGCE	D&T	Graphic Design
8	M		CDT	27	0	B.Ed student	D&T	

Table 16. School 11 Department Characteristics.

Teacher	Sex	Status	'Type'	Age	Yrs	Entry Qual.	ITT Subject	Previous Degree
1	M	H.O.D.	CDT	33	11	B.Ed	D&T	
2	M	2 i.c.	CDT	41	13	B.Ed	D&T	
3	M		CDT	28	4	B.Ed	D&T	
4	M		CDT	34	3	2-Yr PGCE	D&T	Geography
5	M		CDT	42	0	PGCE student	D&T	Fine Art

Table 17. School 12 Department Characteristics.

Contextual Descriptions of the Pupils Involved

Within each school, a group of pupils was brought together for a separate focus group session. The heads of department were asked to arrange for a group of six pupils to be available at a mutually convenient time, without the presence of any teachers, either on the same day as the session with the teachers or on an alternative day. They were simply asked to assemble a representational sample reflecting differing abilities, aptitudes and levels of interest in design and technology; one 'good/successful' and one 'weak/unsuccessful' design and technology student from each of the years. The groups comprised two year 7 pupils (eleven to twelve year-olds), two year 8 pupils (twelve to thirteen year-olds), and two year 9 pupils (thirteen to fourteen year-olds). Once the student groups were arranged, any teachers departed and did not influence proceedings in any way.

The responses to the sessions with the pupils (understandably) varied considerably. Some groups and individuals did not need much prompting while others seemed reluctant to offer very much. On the whole, they tended to be shorter sessions than those carried out with the groups of teachers. More specifically, in one group (school 12) a pupil had been asked, or probably instructed, to join the group during a time when he would normally be doing design and technology, and expressed a desire to return to his lesson. This was dealt with appropriately and it did not disrupt the session in any significant way; in fact this session produced a considerable amount of data. On another occasion (school 8), there was the problem of having an extra pupil present. It was felt that it would be wiser to accommodate the extra pupil rather than releasing her as she might potentially cause disruption within the school during lesson time.

Contextual Descriptions of the 'Experts' Involved

Further triangulation of data was achieved through interviews conducted with so-called 'experts' within the field of design and technology education. Two such sessions occurred:

Experts A

This comprised three people heavily involved in design and technology education initiatives and teacher training. They were brought together for the focus group session during a design and technology conference.

Expert A1 (male) - A lecturer working in higher education at a university, heavily involved in the training of design and technology teachers with a focus on professional studies, including pedagogical issues associated with design and technology teaching.

Expert A2 (male) - Someone heavily involved as a leader of a national project associated with the development of the teaching of design and technology in schools. He originally had a science background. Prior to his current involvement he had worked as a lecturer in higher education at a university and was involved in research and the training of design and technology teachers.

Expert A3 (female) - Someone heavily involved in both the training of design and technology and research into the practice and performance of pupils in design and technology.

Experts B

This comprised of a group of seven Local Education Authority (LEA) inspectors and advisers associated with design and technology. They meet regularly as a regional group.

The geographical region, as represented by this group, tied in with the locations of the sample schools. It was negotiated that part of one of their meetings could be set aside for the purpose of completing a focus group session.

Expert B1 (male) - An LEA inspector of art and design and technology.

Expert B2 (male) - An ex LEA design and technology advisory teacher who now worked as a design and technology consultant.

Expert B3 (male) - An LEA adviser associated with design and technology.

Expert B4 (male) - An LEA general adviser with a responsibility for design and technology.

Expert B5 (male) - An LEA general adviser for design and technology and information technology.

Expert B6 (female) - An LEA general adviser with responsibility for design and technology.

Expert B7 (male) - A retired former LEA adviser for design and technology who still operated as a consultant for design and technology.

Operationalising the Focus Group Sessions

The focus group sessions carried out in schools took place within departments or faculties. The sessions with the teachers tended to occur at the end of a teaching day, often coinciding with their existing schedule of departmental or faculty meetings.

Once the groups were assembled, the nature and purpose of the research was briefly explained, with care being taken to avoid a sense of the research reaching 'desired' results. Working from a prepared prompt sheet (see appendix I), it was indicated that the use of focus group interviewing was to discover issues associated with their involvement in, and experience of, problem solving in design and technology at key stage 3; and that genuine personal consideration of concerns and experiences were sought. (By this time, focus groups had received a 'bad press' through the media reporting on their use within the context of the emergence of 'New Labour', and efforts were made to indicate that they had a purpose within the field of educational research prior to this (Krueger, 1988; Morgan, 1988).)

Issues associated with confidentiality were dealt with at this stage. It was explained that the purpose of recording the sessions was to facilitate data analysis and that it was solely the researcher who would be working from the recorded material and subsequent transcripts.

The group members were initially asked to complete pro formas (see appendix H) which asked them about issues associated with their involvement in teaching. Once again it was emphasised that anonymity would be maintained in the handling of such material by the researcher. Useful information was provided through this approach, in spite of the variance and quality of some of the responses. An obvious observation was the lack of INSET (in-service education of teachers) provision. This was sighted by the majority of teachers within the groups, in terms of generic concerns as well as problem solving within teaching.

The sessions with the groups of pupils occurred during the school day and were arranged by the heads of departments. The actual interviews were conducted without the presence of anyone else other than the selected pupils and the researcher.

A seating plan was made by the researcher of each group which indicated who sat where in order that voices and names could subsequently be matched when transcribing, in order that any longitudinal tracking could occur. To further facilitate this the group were instructed to initially answer the first question in turn. Once this process was completed they were encouraged to participate as fully as possible whenever they felt they wanted or needed to (Krueger, 1988; Morgan, 1988).

The sessions varied but were considered by the researcher to be successful. The 'questioning route' provided a very useful sense of direction and progression. This was exemplified by the number of occasions when it was noted by the researcher that the group was 'anticipating' the next question. One of the hardest aspects associated with conducting the interviews was in maintaining a sense of non-commitment within a role as 'moderator' (Krueger, 1988). For example, care had to be taken when group members asked questions such as: "it depends what you mean by problem solving?". Care was taken over responses to such questions asked by group members, allied to vigilance over bias. Often questions such as that cited above were deliberately not answered, but were 'returned' to the group for their personal consideration. Additional care was taken over the avoidance of cues/clues through body language including facial expressions and the nodding or shaking of the head. The need for the use of additional pre-prepared 'probes' varied between groups and individual questions; generally teachers and 'experts' did not need much probing whereas the pupils needed a greater understandable sense of clarification.

The initial focus groups sessions conducted in the first school with teachers and pupils were considered successful and there was no need for amendment of the questioning route. Feedback was sought and utilised after the initial group sessions to assist the process of evaluation. The positive feedback elicited from the corresponding group of teachers and pupils in conjunction positive self-evaluation confirmed there was no need for modification of the questioning route. As such, the first 'pilot' was included in the subsequent analysis (ibid).

Transcribing the Focus Group Interviews

Each of the 26 focus group sessions were audio-taped and fully transcribed by the researcher. Transcripts of the groups involving teachers and 'experts' averaged approximately sixteen single-spaced pages and those involving pupils averaged approximately ten single-spaced pages. The process of transcribing was completed in turn as soon after each session as practically possible. Care had to be taken over this process due to the nature of the discussion amongst groups as opposed to one-to-one interviews. This often entailed the need for a separate copy of the first round of responses to question one 'dubbed' onto a different tape which could be referred to in order that voices could be matched up to names. This was particularly the case with some of the groups of pupils.

It was decided that the tapes should be transcribed prior to any analysis[1]. Although each tape took at least ten hours to transcribe it did subsequently speed up and aid the processes of sorting and categorising, as well as enable others to verify the analysis (ibid). This process was completed as fully as possible while accepting the impossibility of conveying aspects such as non-verbal communication. However, it was deemed appropriate to adopt the use of certain accepted conventions to take it beyond a sterile script. Italics were used to indicate emphatic stress; three unspaced periods to indicate a pause; a dash to indicate a rapid change of direction of speech; a question mark between forward slashes to indicate words, phrases or sections which could not be deciphered; and a question mark in brackets to indicate a word thought to be correct (adapted and developed from Maykut and Morehouse, 1994). It was considered unnecessary to indicate overlapping speech as such through any graphical representation; instead it was represented as the phasing out of one person and the leading in of another person through the use of three unspaced periods at the beginning or end of those contributions. To compensate for the absence of intonation and characteristics such as sarcasm the presence of laughter has been indicated in places where it was deemed appropriate. Also, it seemed appropriate to include the 'erms' and 'mmms' when people did not speak in crisp statements (Krueger, 1988) and to split overly long sections into discernible chunks

[1] All fully-transcribed interviews, completed by the researcher, are archived within 'Box 1'.

through the use of separate paragraphs. Examples of the conventions adopted and utilised are present in the following contrived example:

C But, in - actually... I don't think it's an *impossibility* because of the nature of the subject to, say, weld this to what you should do... you know...

J The only problem is rooming... that we have to move rooms...

P Moving is a problem.

J ... so you can't... you can't run with the project until it naturally finishes - you do have to...

P Mmm.

L And differentiation - I mean if you've got such a... varied selection of kids and abilities one who can solve a problem... /?/... give the same problem to someone else... /?/... erm... and it's where do you - where's the end(?)... when do you move them on...

C Well, it's suggested that we then talk to each of them individually and guide them...

(laughter)

P But we don't give them time to reflect.

A respresentational sample of fully transcribed interviews can be found in the appendices. These were chosen, simply as, truly representative examples of the processes and outcomes of interviewing and transcription[2]. Appendix J is from a session with a group of teachers; appendix K from the corresponding group of pupils, and; appendix L is from one of the sessions with experts.

Analysis of the Transcripts

Initial analysis of the data from the transcripts utilised the computer software package *Hyperqual2*. This software has a number of options available for qualitative analysis and an appropriate electronic environment had to be created. The 'Structured Interview' option was selected and 'data stacks' were created (figure 7 and 8). The initial part of the analysis process entailed the completion of contextual 'face cards' and transferring of word-processed interview-transcripts into the appropriate stack. The top cards of a stack are designed to enable general project notes to be kept and referred to ahead of the subsequent cards. The data cards are made up of a series of fields of data and function buttons, as exemplified by the following card from one of the interviews:

[2] As previously mentioned, all transcriptions are archived within 'Box 1'.

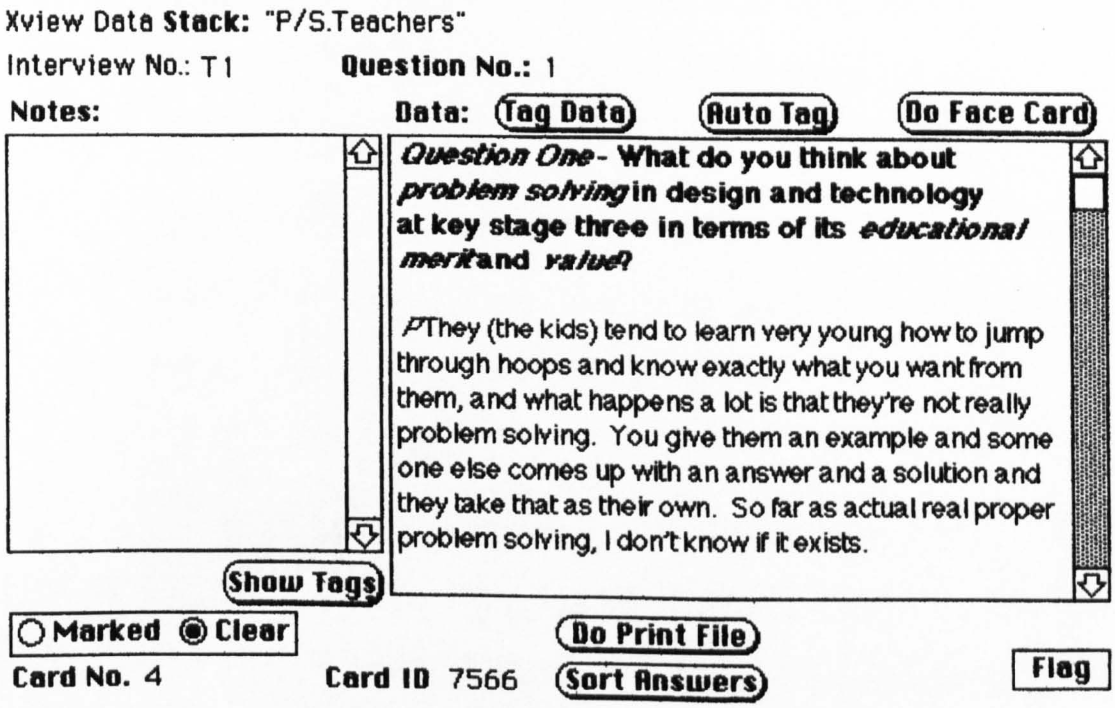

Figure 7. Example of *HyperQual2* Data Stack Card.

Once the transcripts were entered, it was possible to start the process of 'chunking and sorting data' (Tesch, 1993; Padilla, 1993). The iterative process of qualitative data analysis of the interview data involved chunking and reorganising in preparation for an account of the phenomenon under study. This process is based on the following stages or steps:

1. The identification of chunks of data which are meaningful in the context of the emerging account.

2. The retrieval of the chunks from the source data to be isolated in some way in order that they can be utilised in the construction of the emerging account.

3. The further grouping and classification of the retrieved data.

4. The refinement of groups of data in preparation for their role as evidence of the justification for particular claims made in the analysis and final account.

Tesch (1993) refers to this process as one of 'de-contextualising' and 're-contextualising' text segments. Re-contextualisation is accomplished through the searching, sorting, and assembling functions of the qualitative analysis software.

This mirrors the process traditionally carried out with actual physical 'index cards', as indicated by qualitative research commentators (Maykut and Morehouse, 1994; Rubin and Rubin, 1995; Miles and Huberman, 1994). The goal is to identify potentially important experiences, ideas, concepts, and so on, in the data. Consequently, the act of 'discovery' (Taylor and Bogdan, 1984, cited in Maykut and Morehouse, 1994) occurs throughout as recurring ideas and issues emerge through the process of data analysis. Emerging themes can be expressed in various forms such as phrases, propositions or questions.

> The search for meaning is accomplished by first identifying the smaller units of meaning in the data, which will later serve as the basis for defining larger categories of meaning. In order to be useful for analysis, each unit of meaning identified in the data must stand by itself, i.e., it must be understandable without additional information, except for knowledge of the researcher's focus of inquiry (Lincoln and Guba, 1985). Note, however, that units of meaning in an interview transcript may be in response to a question that needs to be included with the unit of meaning to make sense.
>
> (Maykut and Morehouse, 1994: 128)

The source data, in the form of the transcripts, were scanned for potentially meaningful chunks. This entailed reading through the discussion 'on screen' and highlighting chunks of words, in the form of statements, discussion, claims and so on, and either creating a new category or label, or alternatively placing the chunk into an existing labelled category. This process of coding the data, in terms of the software utilised, is referred to as ‘tagging’ (Tesch, 1993; Padilla, 1993). For instance, on reading a section of the group discussion in response to question 6 involving teachers in school 11 it seemed that the following section emerged as an issue:

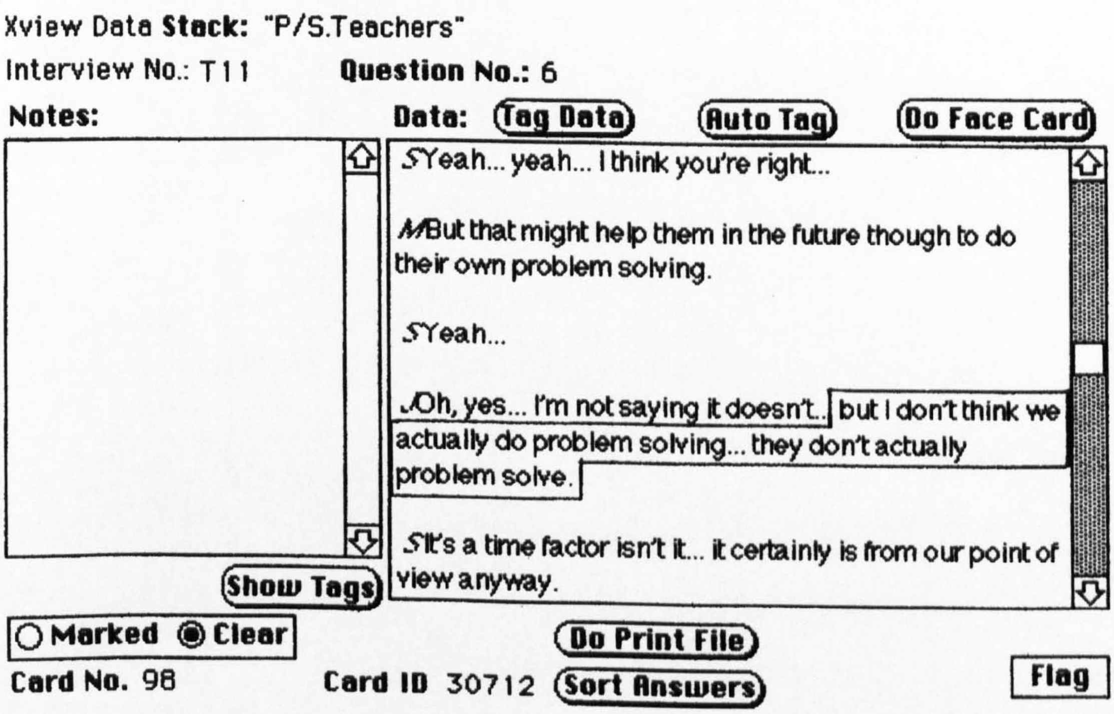

Figure 8. *HyperQual2* Data Stack Card – Example of Formative Tagging Process.

The ‘Tag Data’ button is therefore seen as central to the operation of *HyperQual2*. Its function is to allow the researcher to segregate chunks of data from a data stack without disturbing the original data. The selected chunks of data are transferred to ‘Exemplars Stacks’ (figure 9 to 14) which are effectively created by the researcher but, most importantly, can be considered as emerging naturally from the data. As the researcher scans the data cards, chunks of data can be selected by highlighting the text, by dragging the mouse over the selected section. Once the chunk of text is selected, the ‘Tag Data’ button is operationalised by clicking the mouse on it. This process causes a copy of the selected data chunk to be transferred to a separate 'Exemplars Stack' that may by then hold other chunks:

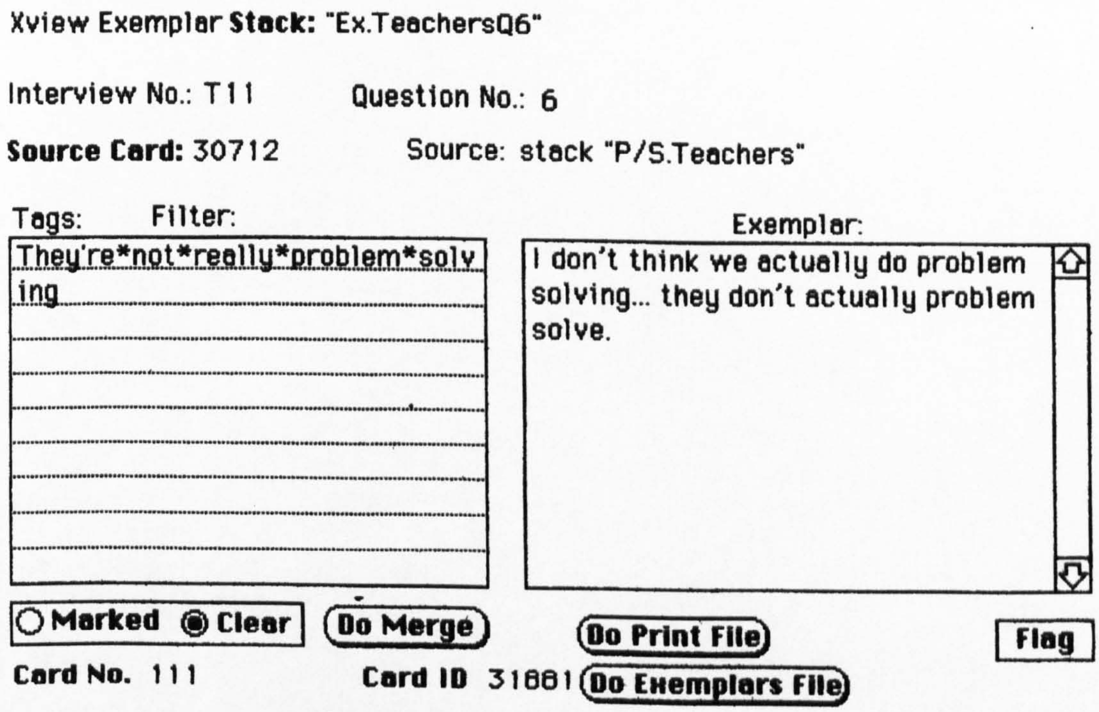

Figure 9. Example of *HyperQual2* Exemplar Stack Card.

As part of this process the researcher/analyst can tag (or code) the data chunk and export both the chunk and its tag or tags to the 'Exemplars Stack'. It can be seen that the issue which arose from the featured example was tagged, or categorised, as 'They're not really problem solving'[3] (figure 10). The label emerges as part of the scanning process, and once a category is initially formed it can then have any text of a similar nature added to it.

[3] The use of the asterisks in the cited example denotes the inclusion of spaces – in line with the relative limitations of the *HyperCard*-based software.

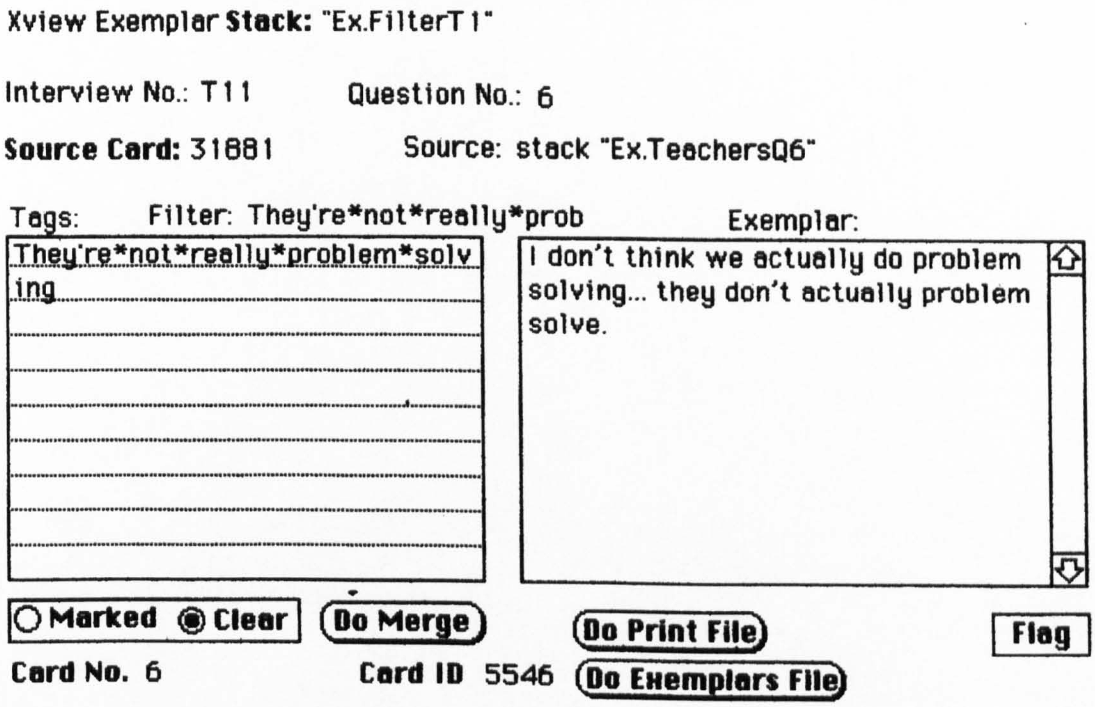

Figure 10. Example of *HyperQual2* Exemplar Stack Card with Designated Filter.

It is possible to highlight text a number of times as it might be considered appropriate to place the same 'data' into a number of differing 'tags'. For example, within a section of transcript in response to question 3 with the teachers in school 6 there was a statement associated with 'positive feelings', and a sub-section of this included an 'example of problem solving':

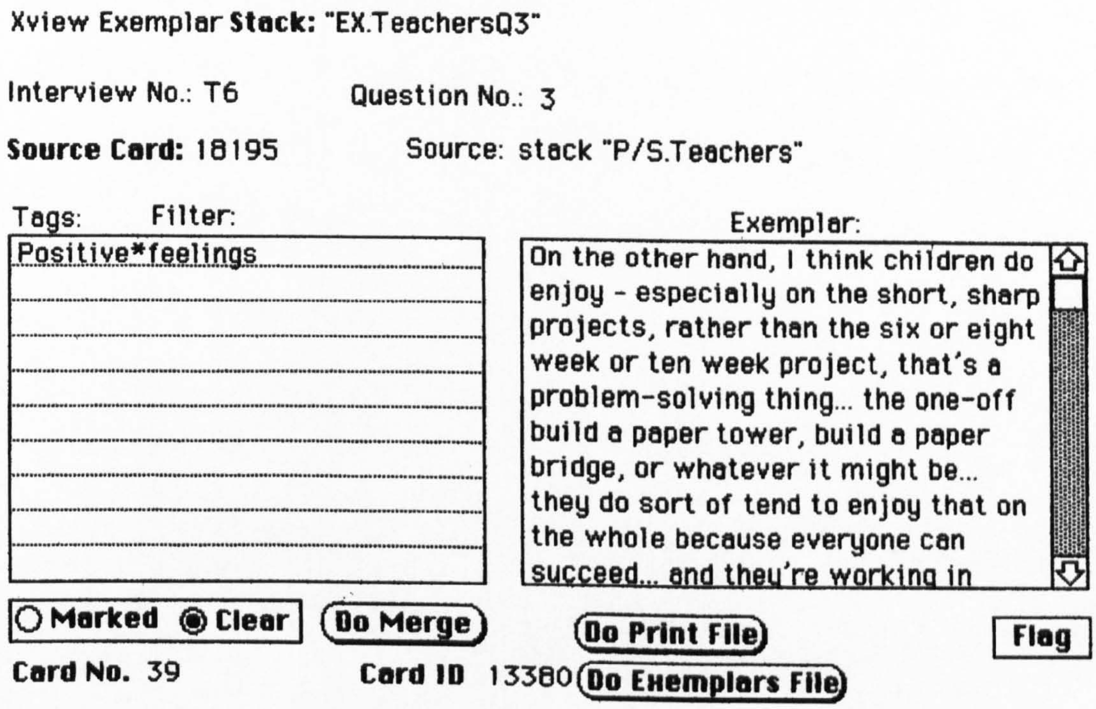

Figure 11. Example of *HyperQual2* Exemplar Stack Card with Data Placed in Tag.

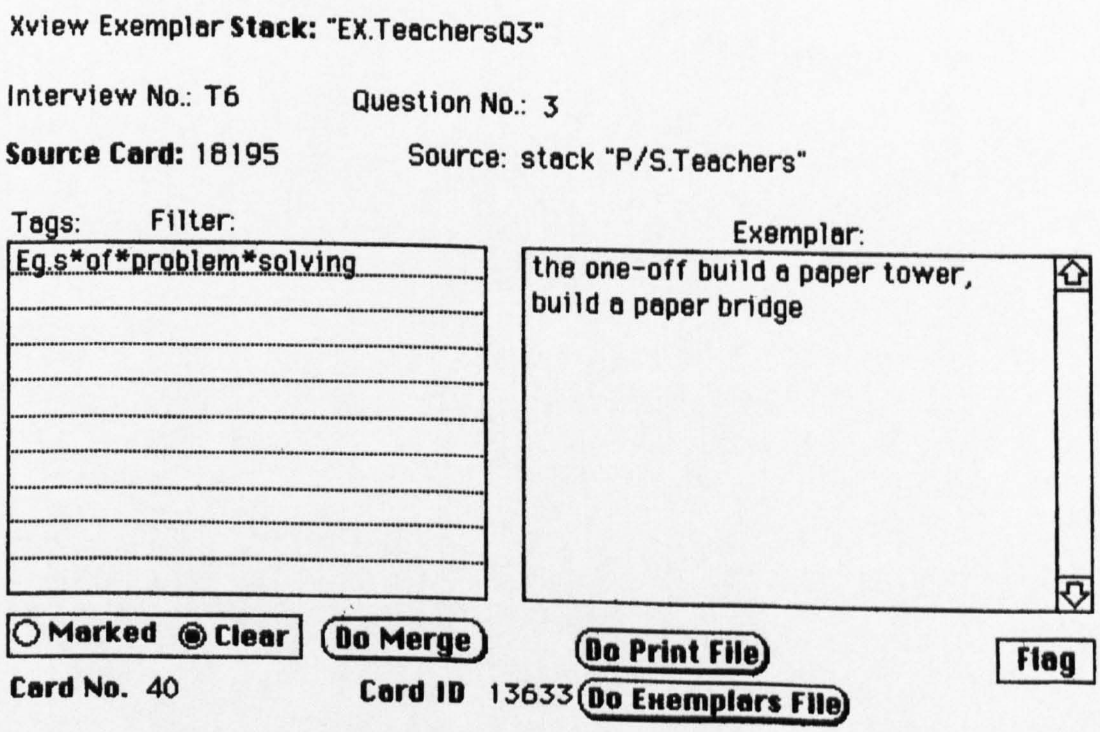

Figure 12. Example of *HyperQual2* Exemplar Stack Card with 'Common Data' Placed in Further Tag.

At other times an 'identical' section of text could be attributed to 2 different tags. For example, within the 'response' to question 2 with teachers in school 4 a section was tagged as both 'teaching and problem solving' and 'models of problem solving':

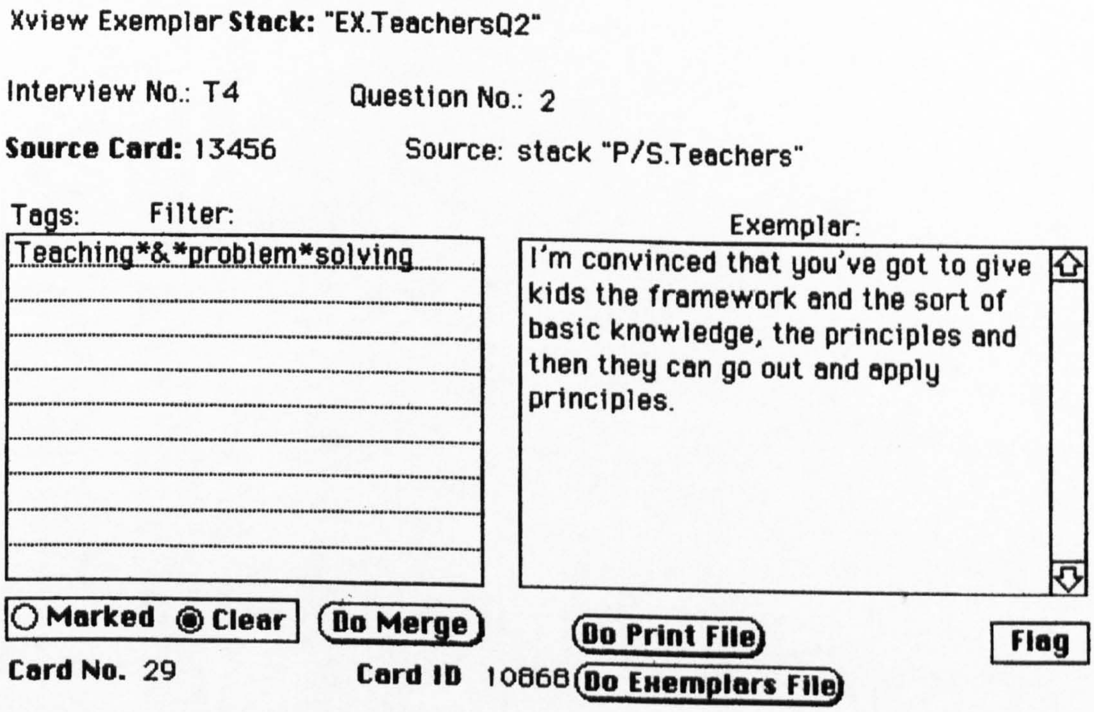

Figure 13. Example of HyperQual2 Exemplar Stack Card with Data Placed in Tag.

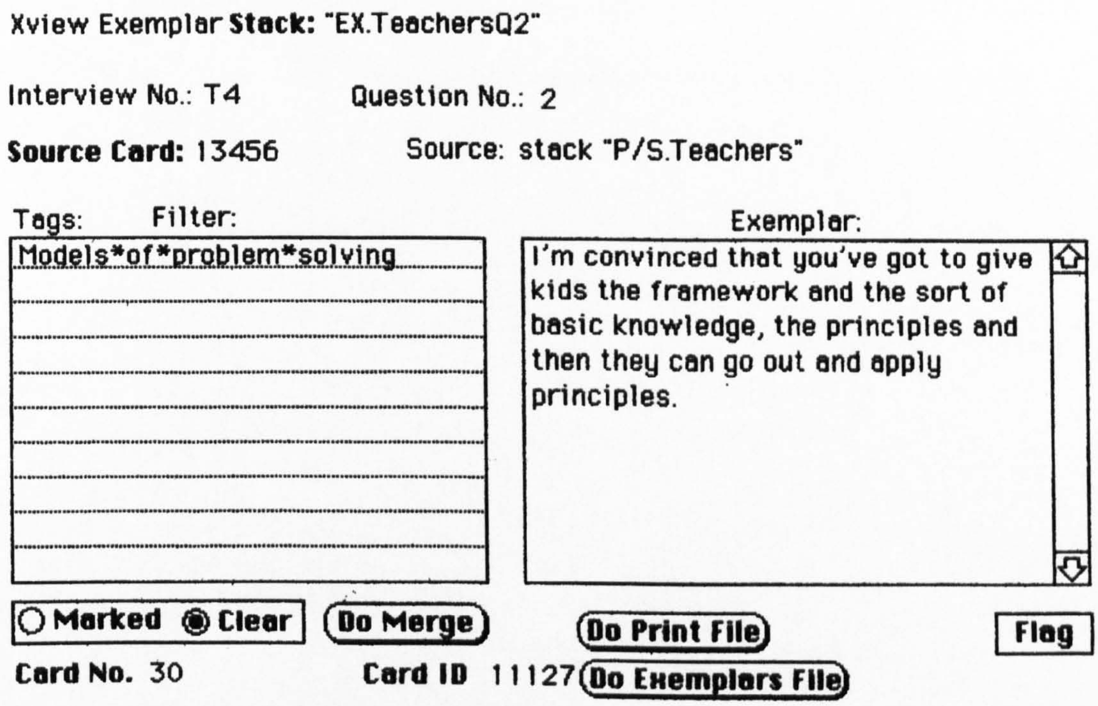

Figure 14. Example of *HyperQual2* Exemplar Stack Card with 'Identical Data' Placed in Subsequent Tag.

It can be seen, therefore, that the established process of categorising and coding is carried out through the utilisation of the *HyperQual2* software, with the researcher seeking to develop a set of categories that provide a reasonable reconstruction of the data collected through the group interviews. Effectively, this encompasses the adoption of the 'look/feel-like criteria' as advanced by Lincoln and Guba (1985, cited in Maykut and Morehouse, 1994) as a way of describing the emergent process of categorising qualitative data. The researcher systematically draws together similar units of meaning in a systematic way and 'salient categories of meaning are inductively derived' (Maykut and Morehouse, 1994: 136).

At this stage the researcher has effectively developed a 'tag list' for each set of interviews; in this case: one for the interviews with the teachers (table 18); one for the interviews with the pupils (table 19); one for the interview with 'experts a' (table 20); and one for the interview with the 'experts b' (table 21). A relational pattern can be identified when all of the tag lists are presented in the form of a compendium (table 22).

Tag list for stack: (Problem Solving) Teachers
Access to info
Actual problem solving doesn't exist
Characteristics of problem solving
Creativity = problem solving
Definitions of problem solving
Different types of problem solving
Difficulties
Dilemmas
Eg.s of problem solving
Hierarchy of problem solving
Inset
ITT & problem solving
Justification for problem solving
Learning & problem solving
Models of problem solving
Negative feelings
Only problem solving in bits that they do
Positive feelings
Previous experience
Problem solving & creativity
Problem solving & designing
Problem solving, creativity & designing
Problem solving particular to D&T
Pupils' differing abilities
Raised awareness
Relevance of projects
Scenarios
Teachers not describing problem solving
Teaching & designing
Teaching & problem solving
They're not really problem solving
Transferability

Table 18. Tag List for Teachers 'Interviewed'.

Tag list for stack: (Problem Solving) Pupils
Characteristics of problem solving
Different types of problem solving
Difficulties
Eg.s of problem solving
Hierarchy of problem solving
Justification for problem solving
Learning & problem solving
Mixed feelings
Negative feelings
Positive feelings
Problem solving & designing
Problem solving particular to D&T
Raised awareness
Relevance of projects
Teachers making it easier
Teachers making it harder
Teaching & problem solving
They don't appear to do it
Transferability
Uncertainties over what it is

Table 19. Tag List for Pupils 'Interviewed'.

Tag list for stack: (Problem Solving) Experts A
Access to info
Associated research
Characteristics of problem solving
Definitions of problem solving
Different types of problem solving
Difficulties
Eg.s of problem solving
Inset
Learning & problem solving
Models of problem solving
Negative feelings
Positive feelings
Problem solving & creativity
Problem solving & designing
Problem solving particular to D&T
Progression
Pupils' differing abilities
Skills & problem solving
Teaching & problem solving

Table 20. Tag List for Experts Group A 'Interviewed'.

Tag list for stack: (Problem Solving) Experts B

Access to info
Characteristics of problem solving
Definitions of problem solving
Different types of problem solving
Differentiation & problem solving
Difficulties
Inset
Learning & problem solving
Negative feelings
Positive feelings
Problem solving & creativity
Problem solving & designing
Problem solving & learning styles
Problem solving & thinking styles
Problem solving particular to D&T
Progression & problem solving
Teaching & problem solving
Technical skills & problem solving

Table 21. Tag List for Experts Group B 'Interviewed'.

	Teachers	Pupils	Experts A	Experts B
Access to info	■		■	■
Actual problem solving doesn't exist	■			
Associated research			■	
Characteristics of problem solving	■	■	■	■
Creativity = problem solving	■			
Definitions of problem solving	■		■	■
Different types of problem solving	■	■	■	■
Differentiation & problem solving				■
Difficulties	■	■	■	■
Dilemmas	■			
Eg.s of problem solving	■	■	■	
Hierarchy of problem solving	■	■		
Inset	■		■	■
ITT & problem solving	■			
Justification for problem solving	■	■		
Learning & problem solving	■	■	■	■
Models of problem solving	■		■	
Mixed feelings		■		
Negative feelings	■	■	■	■
Only problem solving in bits that they do	■			
Positive feelings	■	■	■	■
Previous experience	■			
Problem solving & creativity	■		■	■
Problem solving & designing	■	■	■	■
Problem solving & learning styles				■
Problem solving & thinking styles				■
Problem solving, creativity & designing	■			
Problem solving particular to D&T	■	■	■	■
Progression			■	
Progression & problem solving				■
Pupils' differing abilities	■		■	
Raised awareness	■	■		
Relevance of projects	■	■		
Scenarios	■			
Skills & problem solving			■	
Teachers making it easier		■		
Teachers making it harder		■		
Teachers not describing problem solving?	■			
Teaching & designing	■			
Teaching & problem solving	■	■	■	■
Technical skills & problem solving				■
They don't appear to do it		■		
They're not really problem solving	■			
Transferability	■	■		
Uncertainties over what it is		■		

Table 22. Tag List Compendium

Within this process it was possible to utilise an iterative approach to the process of analysis. It was seen that initial scanning could be quite coarse but become a finer process as the emerging account drove the search for particular kinds of evidence. For each iteration of the process, retrieved data chunks can be sorted in relevant ways. For example, once the source data are scanned and categorised through the process of tagging, the homogeneous set of chunks can be further scanned for exceptions, contradictions, or negations within the context of the emerging account (Maykut and Morehouse, 1994; Rubin and Rubin, 1995). Once the data chunk is in the 'Exemplars' stack, it can be further tagged and sorted as required within an iterative approach to seeing issues emerge. However, by this stage it seemed preferable to visually group associated emergent concepts and issues as a way of bringing, 'relevant data together in a way that will encourage the drawing of conclusions' (Robson, 1993: 390). Therefore, a process of graphical mapping was carried out in a similar way to that conducted within 'cognitive mapping' (Miles & Huberman, 1994) or 'mind mapping' (Buzan, 1977) (table 15 to 22):

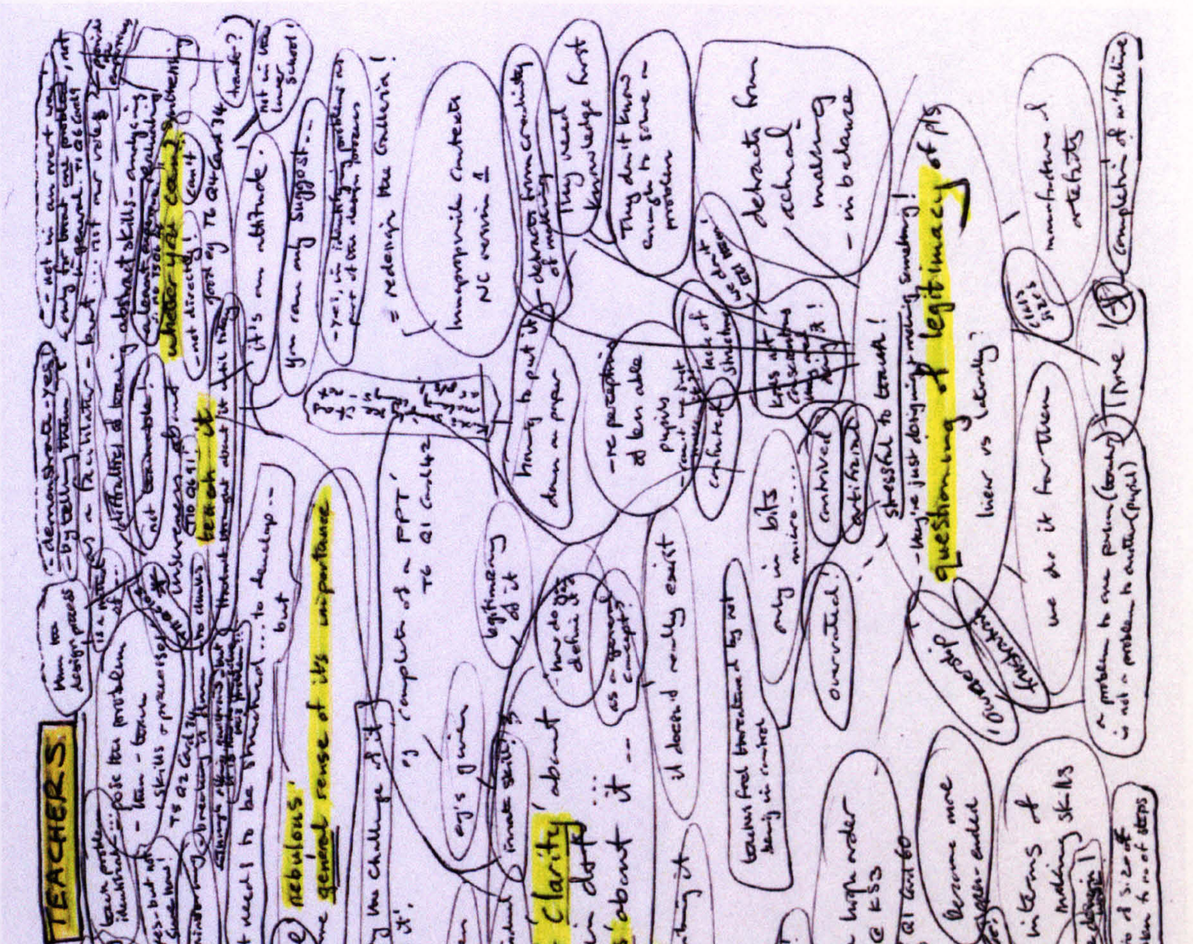

Figure 15. Cognitive Map 1.

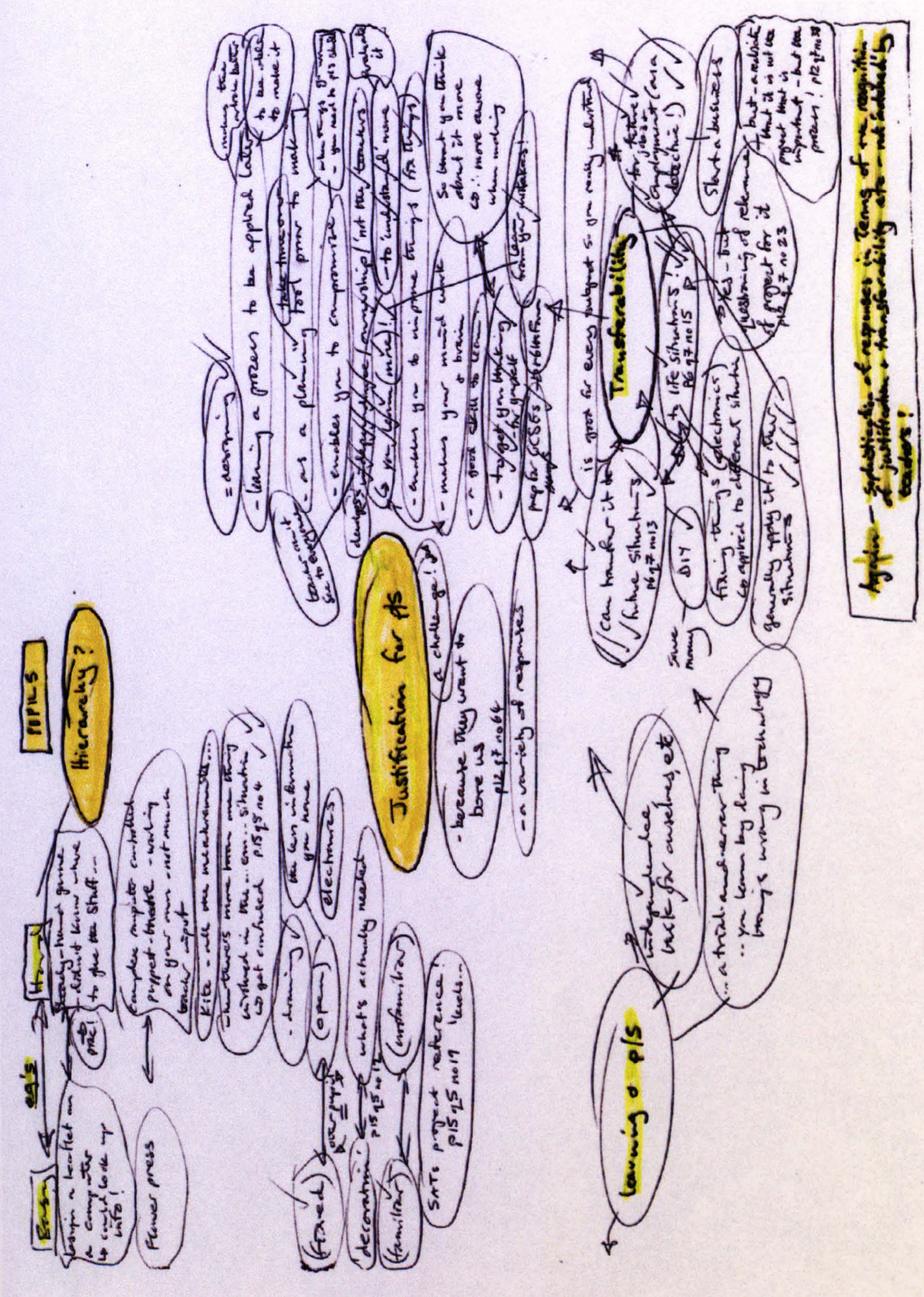

Figure 16. Cognitive Map 2.

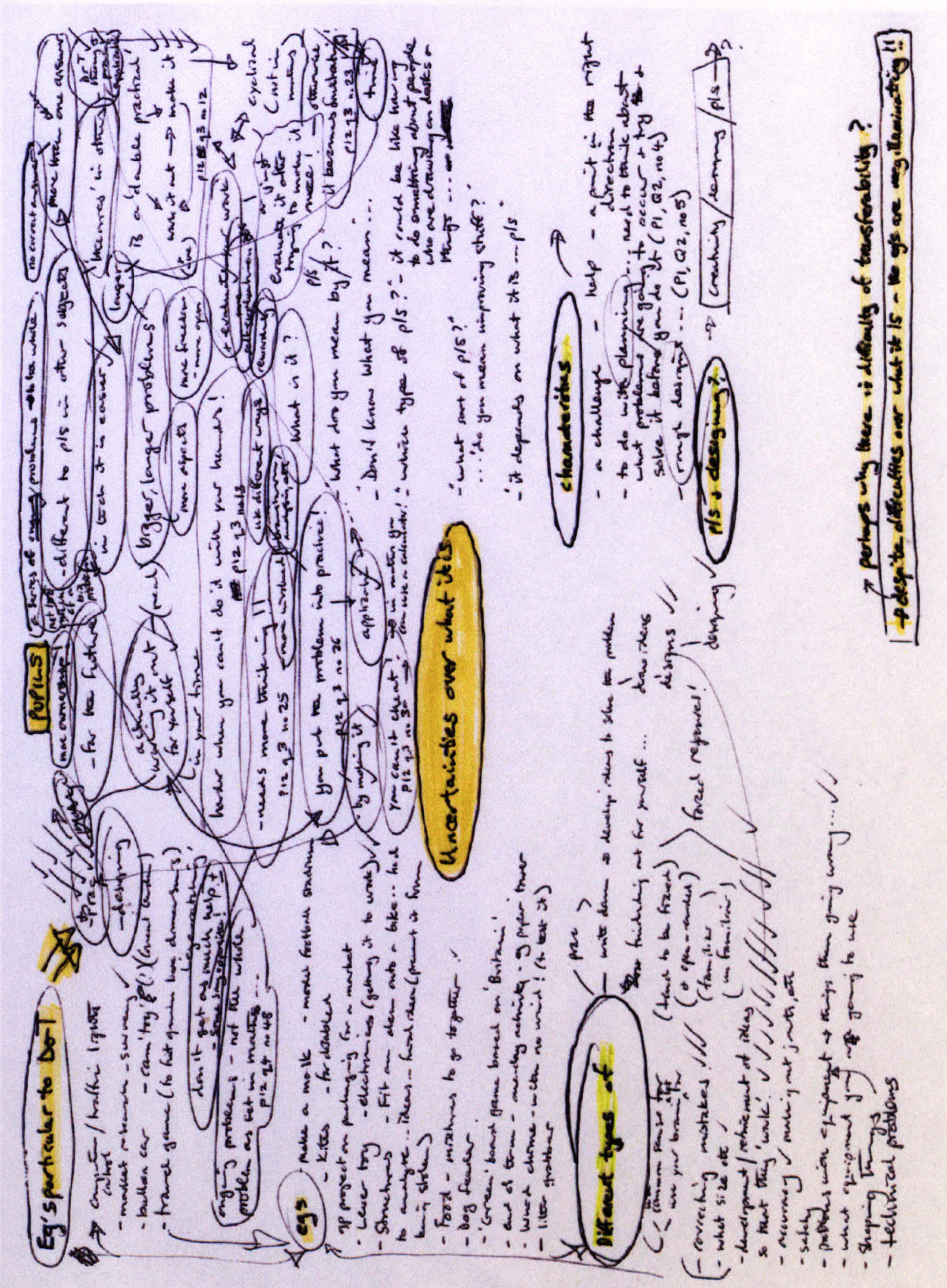

Figure 17. Cognitive Map 3.

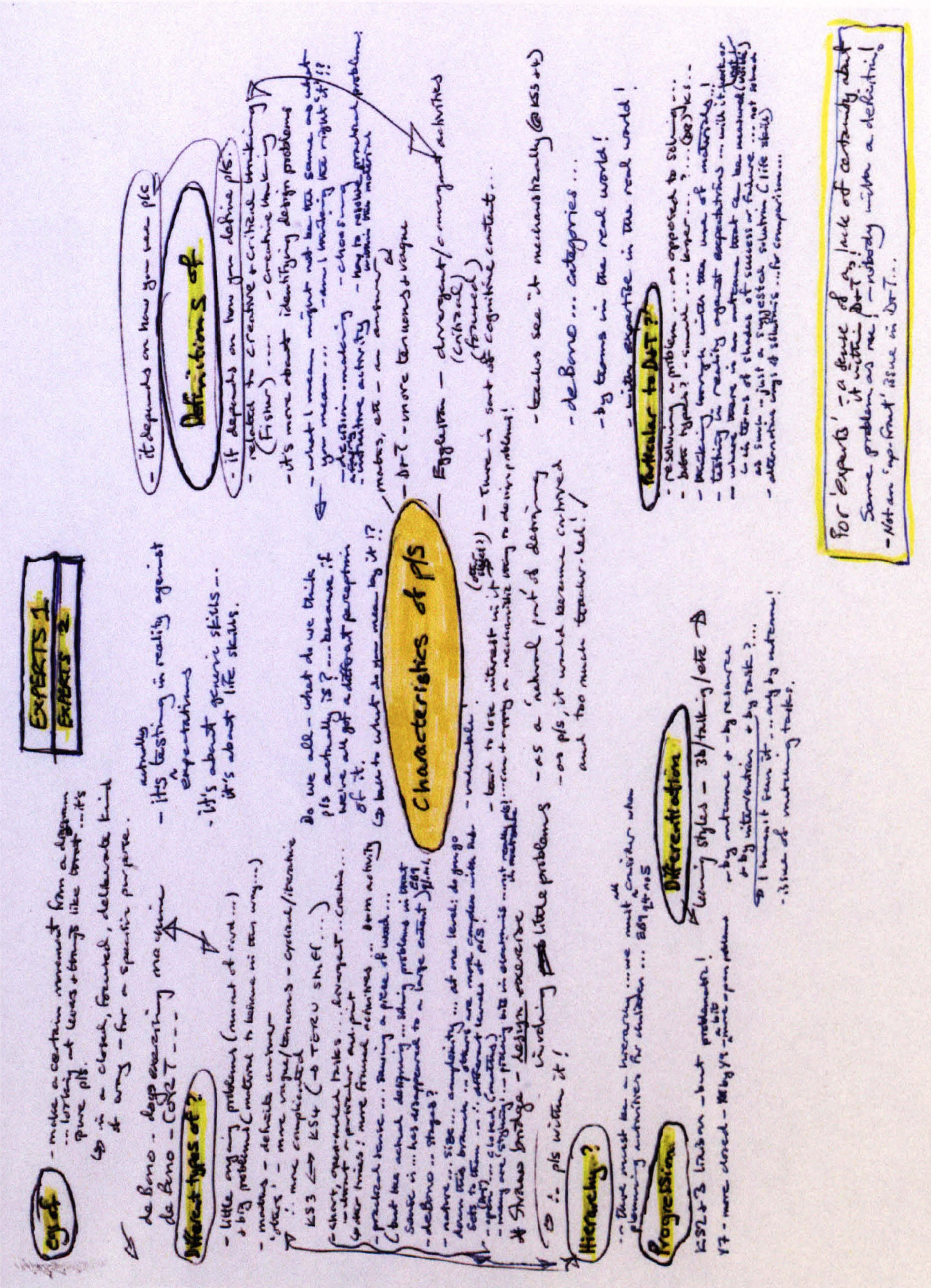

Figure 18. Cognitive Map 4.

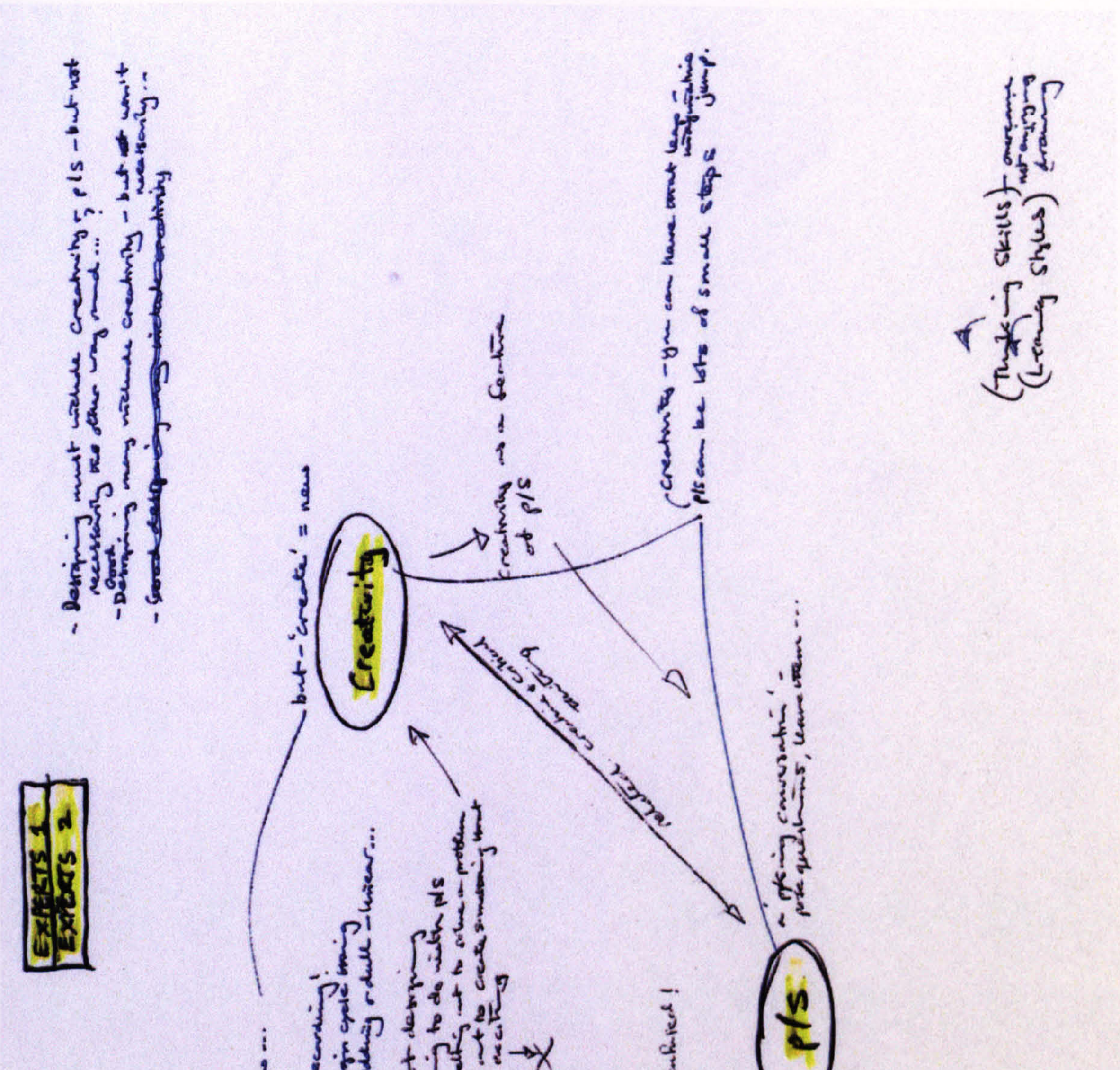

Figure 19. Cognitive Map 5.

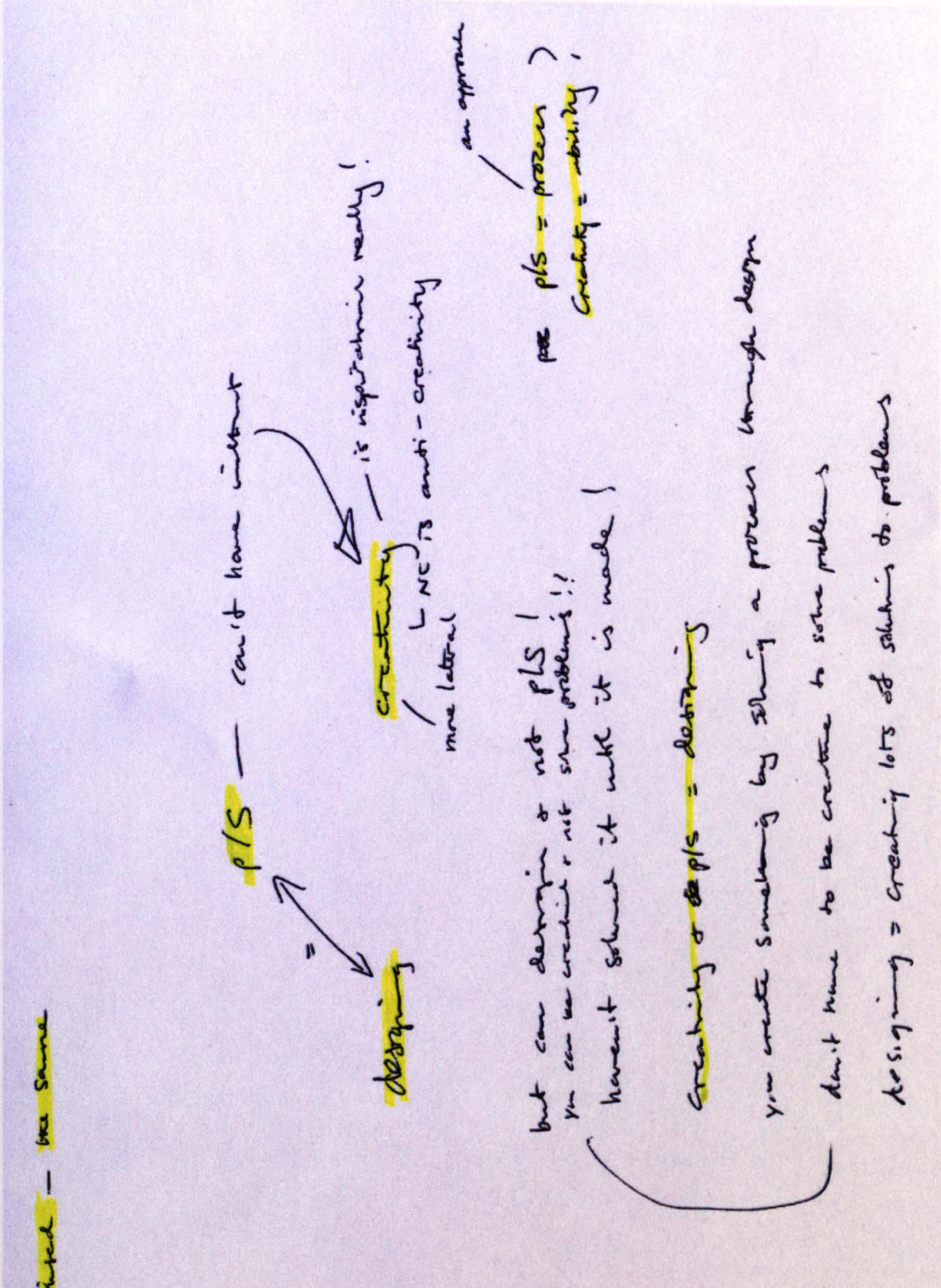

Figure 20. Cognitive Map 6.

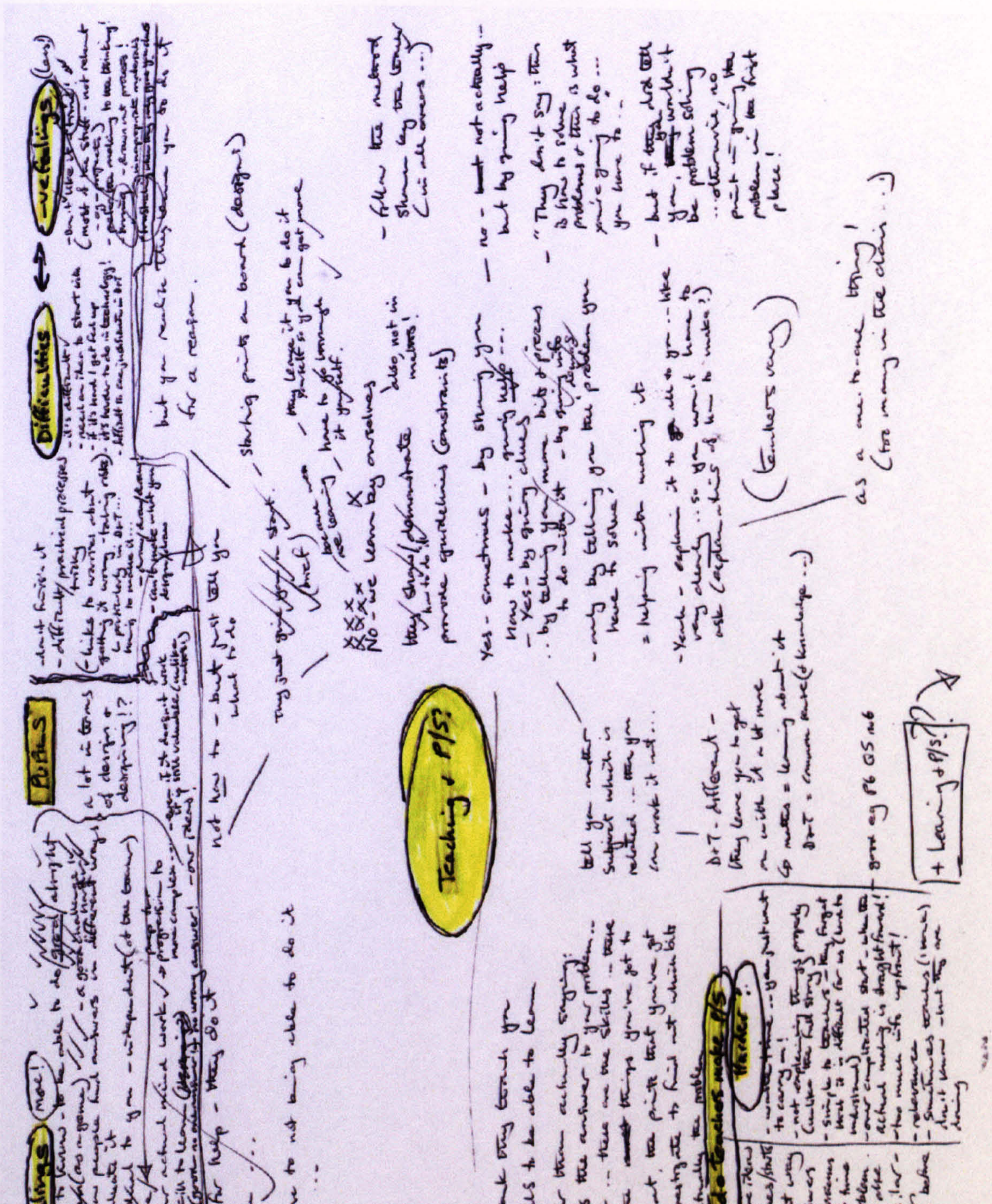

Figure 21. Cognitive Map 7.

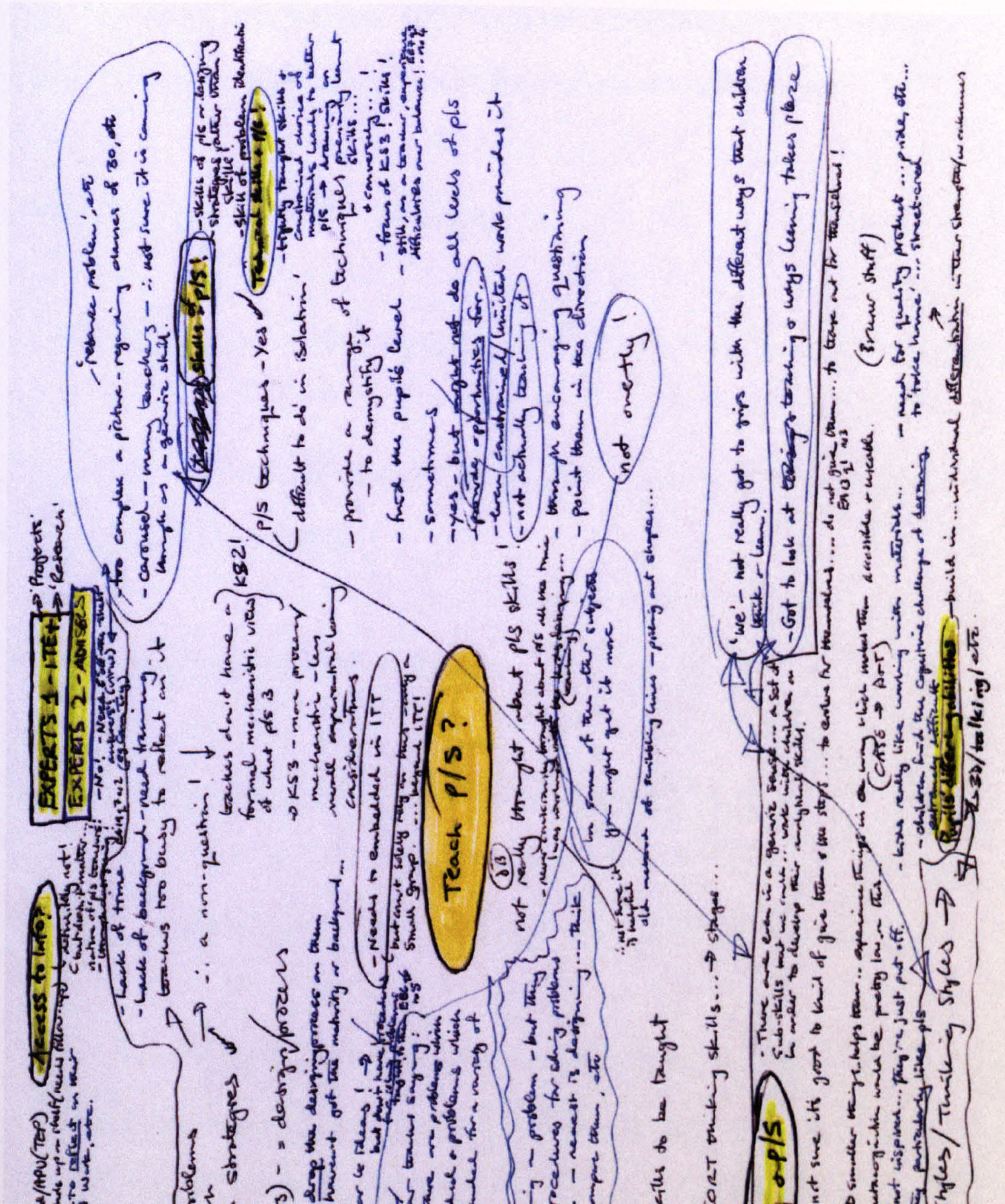

Figure 22. Cognitive Map 8.

This analysis provided data which could be utilised in a number of ways to varying depths. The larger issues emerging could be grouped in the following way:

- Perceptions of what problem solving is

- Value judgements in terms of legitimacy, justification and validity of problem solving

- Positive and negative feelings and experiences associated with teaching and learning involving problem solving

- Whether problem solving can be taught

- Interpretations of any hierarchical structure of problem solving

- Degree of identified knowledge and training associated with problem solving

Some of these emerged as an amalgam of responses within the focus group sessions as a whole, whereas an issue such as 'teaching of problem solving' was mostly directly related to a specific question. The nature of the data and analysis enabled any desired tracking of individual issues as well as 'lines of thought' from an individual. In the case of the teachers and experts a further cross-referencing could be made to background material of that individual.

Summary

This chapter presented explanations and descriptions of research implementation. Heads of departments were approached within the schools and subsequent focus group sessions conducted with both staff and corresponding groups of key stage 3 pupils. Additional focus group sessions were completed with two groups of 'experts'; one group comprised advisers and inspectors associated with the schools, and the other comprised national figures within design and technology education.

The 26 focus group sessions were recorded (through the use of a audio-tape recorder) and fully transcribed. The resultant transcripts were analysed, using the 'constant comparative' method, with the aid of the computer software package *Hyperqual2*. 'Chunks of data' were developed into salient lists of concepts. These concepts were then further refined, in conjunction with the process of 'cognitive mapping', to enable consideration and discussion of emergent themes.

Chapter 5 Findings

Major Findings

During analysis of interview data, emerging themes were considered from the perspective of the three distinct categories of interviewee groups, leading to overall thematic findings.

Teachers

'Lack of clarity about what problem solving is - unsureness about it'

One of the major impressions emergent from the analysis of data is the lack of clarity about the 'promoted' central concept of problem solving within design and technology, exemplified from responses ranging from a consideration of 'it doesn't really exist' through to being an 'innate individual quality' to 'it is a very good thing but too nebulous in nature'.

Although the declared focus of the group interviews with teachers was that of problem solving within key stage 3 design and technology, on reflection, teachers often did not talk directly about problem solving itself. At such times, during the discussion of issues, it was noticeable that they were not really describing problem-solving scenarios. In particular, this linked to any definitions offered and interpretations of the relationship between the design process and problem solving. Indeed there were occasions when individual teachers would ask 'how do you define it?', in addition to seeking distinctions between a general notion of problem solving and that which might occur within design and technology.

Often problem solving was equated to other aspects, on the following bases:

- problem solving = the design process;
- problem solving = thinking processes;
- problem solving = decision making;
- problem solving = drawing, not making;
- problem solving = design and make tasks;
- problem solving = leaving them to it, (for example, a design problem).

In terms of the relationship between 'problem solving', 'creativity' and 'designing', many relational combinations were expressed:

- problem solving = designing;
- but, you can design and not problem solve;
- you can be creative and not solve problems;
- you don't have to be creative to solve problems;
- you can not have problem solving without creativity;
- creativity + problem solving = designing;
- you create something by solving a process through design;

- designing = creating lots of solutions to problems;
- you haven't solved it until you have made it;
- creativity is more lateral;
- creativity is inspirational really;
- the national curriculum (D&T) is anti-creativity;
- problem solving is an approach, creativity is an ability.

and, in terms of 'a problem':

- a problem = design brief;

and, conversely;

- a problem = not a design brief.

However, when individuals did provide examples of problem solving they often cited the bridge structures project as being the most obvious within the context of design and technology. Other examples cited were: desert island survival (in groups); one-off short-term activity based on paper-tower building exercise; weights project using a number of provided components; and, pull-string toy.

It became clear very quickly that while there is recognition of a variety of interpretations of problem solving they vary considerably within the context of design and technology. Respondents considered specific problem solving as 'egg-race' type projects, and, to a lesser extent, 'transient problems' (McCormick & Davidson, 1996) encountered within the broader experience of manufacturing designs. A general assumption is made that (generic) problem solving will be experienced by pupils as a result of being involved in processes associated with designing and making.

'Questioning of legitimacy or validity within key stage 3 D&T'

Many cited 'pressures' which detracted from the inclusion of emphasis on problem solving within key stage 3 design and technology. For example:

- time;
- class sizes;
- lack of physical resources;
- pupils' lack of sufficient knowledge and skills;
- having to manufacture design ideas and artefacts (solutions to problems);
- having to commit detailed design development on paper;
- it's a different way of learning in secondary school (as opposed to primary school).

These could be seen to link to further aspects raised:

- it is stressful to teach, linked to 'ownership' of process and teachers feeling threatened by not being in control;
- it is quite 'high-order' and therefore not applicable for key stage 3;
- it is overrated, contrived and artificial (having to put it down on paper), lacks structure, 'confused' (linked to national curriculum version 1 – for example, the redesigning of a shopping mall);

- pupils do not know enough to solve the problem, and need knowledge first, which detracts from the creativity of making;
- we do it for them;
- they are not conscious they are doing it, and we do not tell them;
- kids see the subject as making things, not as problem solving, which is linked to the perception of less-able pupils' negative feelings and frustration.

Also, some expressed the fact that either pupils do not like taking risks and making mistakes or are scared of getting it wrong. Links were made to the perception of the national curriculum mitigating risk taking.

Many of the concerns expressed apparently affected teaching and learning performance beyond the specific inclusion of problem solving. It appears that designing, the aspect most closely aligned to interpretations of problem solving by the teachers, is the weakest component of the subject from the perspective of department inspections carried out by *Ofsted*[1]. Many teachers of design and technology obviously feel more comfortable and confident in teaching associated with the manufacturing of artefacts. The additional consideration of problem solving, allied to designing beyond handling 'transient problems', creates situations seen to be too flexible and broad-ranging. Consideration of greater use of aspects such as problem solving are considered additional to the 'status quo', rather than any realigned balance between 'open-ended problem-solving based designing' and the 'manufacturing of artefacts'. This links to the claim that there should be a greater consideration of the purpose of designing which is committed to paper, as

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[1] Substantiated by specific departmental observations within *Ofsted* school inspection reports as well as yearly *Ofsted* reports.

expressed by one of the Local Education Authority inspectors in terms of the teachers' own approach as well as the influence of exam boards. Also, 'emphasis on 'making' can lead to the neglect of the design process and problem solving skills in technological education' (McCormick & Davidson, 1996: 230). Once again, it is arguable that problem solving does not have to be considered in a 'discreet' or 'overt' way, as it will automatically happen as a result of involvement in typical design and technology activity.

'Questioning whether you can teach problem solving'

There were a noticeable number of responses indicating that the teachers had not consciously thought about the concept of teaching problem solving prior to the interview sessions.

One teacher who did think that you could teach it subsequently acknowledged however that he/she was unsure how this might occur.

Many considered that it was 'learnt experience' or an 'attitude', and that you cannot actually teach it, because 'it is not teachable'. Specifically, it was considered that it cannot be taught at key stage 3, which linked to expressed difficulty over teaching abstract skills such as analysing, evaluating and synthesising. Others considered that you cannot teach it in an overt way, but that you can provide experiences for pupils to problem-solve within, as a 'facilitator', through demonstrations.

Those who considered that it could be taught often associated it with the design-process structure. Also, it was proposed that you can teach it for that one specific problem but not in a general sense.

Other examples associated with teaching problem solving included:

- you pose the problem and then teach them the skills and processes needed;
- through teaching problem identification;
- it is brainstorming;
- through providing hints and suggestions;
- by breaking it down into chunks;
- by asking questions (but it was "how do you solve this problem?").

Such responses confirm the domination of 'the design process' over wider pedagogical considerations. We may deduce from this that effectiveness of teaching associated with problem solving might correspond to an individual teacher's competence in terms of handling problem solving processes within an educationally orientated design and technology environment. It is noticeable that the emphasis of material emanating from the UK has been dominated by the design process while that from the USA has focused more on educational issues, linking back to Dewey's influence relating to the importance of the process of problem solving within the whole curriculum (Yi, 1996). Consequently, a greater overt, and potentially influential, consideration of 'teaching problem solving' is evident in material from the USA, as opposed to that within the UK. However, the examples cited by some of the teachers, such as brainstorming, breaking problems down into manageable chunks, and effective questioning, do correspond to strategies featured within material associated with effective 'teaching of problem solving'. Teachers, however, are unsure about the extent of help and assistance which might be deemed legitimate within their role in teaching based on open-ended design briefs.

'Varied interpretation of any hierarchical structure of problem solving'

Very few teachers made conscious links to any 'theoretical framework' based on levels of operation.

One of the schools had recently had a whole-staff development session on levels and types of thinking, and this was acknowledged by a couple of members of the department who positively referred to 'levels of operation' being an important consideration within design and technology. Other fairly isolated cases included links made to: Piaget; cognitive approaches; cognitive processes; and, 'cognitive leap'.

Identified factors associated with hierarchical structure were, however, evident within responses based on considerations of progression and differentiation.

In terms of differentiation, most fell into line with the concept of:

- 'differentiation by outcome' (and working to their own level).

Others included differentiation:

- by process;

- by language;
- by support;
- by how much you tell them.

In terms of progression and any hierarchical structure, responses included:

- the size of the problem;
- becoming more open-ended;
- bigger leaps;
- more design work;
- in terms of making skills;
- how much you tell them;
- how much you help them;
- going beyond the 'concrete';
- it's getting them to go through the old cognitive processes isn't it.

An additional comment was to the effect that the highest level was where there was no answer.

Within the development of design and technology there has been a reluctance to accept alternative models of differentiation beyond that based on outcome - reflecting, once again, the reliance on the design process as facilitating or enabling appropriately varied responses by individuals. However, a noticeable shift has occurred towards broader interpretation of differentiation. For instance DATA (The Design and Technology Association) guidance for heads of design and technology departments identifies that:

> Differentiation by outcome is clearly an important aspect of differentiation in design and technology. However, it is only one of several aspects that need to be considered in order to maximise students' achievements. Students cannot validly be assessed in relation to an outcome only. The following should also be considered:
> - teaching strategies, methods, pace and language
> - use of teaching materials and resources
> - task and context of learning
> - level of teacher intervention provided
> - level of autonomy and choice offered to students.
>
> (Design and Technology Association, 1997: 3.1.4)

The issue of progression is also covered within such guidance, in conjunction with the concept of continuity, and it is suggested that:

> The following opportunities for progression should be addressed:
> - students taking increased responsibility for their own learning and the management of it, e.g., movement to more student-determined tasks and student-identified targets
> - complexity of the task undertaken which is dependent upon the criteria within the brief
> - students meeting a variety of needs in their designing
> - the number and complexity of issues addressed and attitudes and values explored
> - students' awareness of the impact of technology on people's lives
> - the levels of research, investigation and evaluation undertaken
> - range and depth of knowledge and understanding required and used
> - the development and application of skills and processes
> - the breadth of contexts, materials, tools and equipment experienced
> - students acquiring a developed awareness of themselves as learners and in relation to the progress they are making.
>
> (ibid: 3.1.3)

Such guidance is helpful. However, responses from teachers indicate a lack of 'science' in terms of legitimacy of mediation. Further guidance from the same handbook considers the positive role of teacher intervention, whereby:

> Teaching children to be autonomous and independent workers in design and technology means students being supported to develop their own ideas and make decisions. It should not mean them working unsupported.
>
> (ibid: 3.1.5)

However, it is for teachers to make appropriate decisions associated with such aspects, since, 'Teachers' professional judgement is a key element in the decisions they will need to make about the type and level of support which is appropriate at any point in time...' (ibid: 3.1.5).

This situation is compounded by the demands of measured assessment of pupils' work allied to indicating performance within the 'processes of design and technology'. In an obvious sense, manufactured outcomes are more tangible and quantifiable.

'Identified lack of 'training' about problem solving'

Overall, responses pointed towards a lack of INSET provision, generally as well as in relation to problem solving. One exception was an LEA course on 'Learning for a Changing World' which occurred six years prior to the interview. Also, some reference was made to TVEI (Technical and Vocational Education Initiative). In addition to the lack of courses, there was a plea for help ("we need it"). One commented in response that they needed a course in problem solving!

Consistently, references were made to the absence of any specific training associated with problem solving on any ITT course ('old' or 'new'). Therefore, there was an expressed feeling of not being trained for it (some more experienced teachers described themselves as being 'pre-design and technology'. However, there was some recognition of involvement during initial degree courses (prior to PGCE [Post Graduate Certificate of Education] courses), management courses, or personal industrial experience (but not of a very sophisticated nature).

Respondents made references to influential problem-solving materials such as the Schools Council publication entitled 'Problem Solving'[2] (part of the Modular Courses in Technology series aimed at 14- to 18-year-olds) and 'Education Through Design and Craft, Materials and Design'[3] (part of the series of books from the Design and Craft Education project). Some additional reference was made to the work of Edward de Bono.

Pupils

'Teachers don't actually teach you how to problem solve'

Many pupils considered that problem solving can not be taught because they learn it themselves. Such responses were from those who seemed to grasp the concept of problem solving as distinct from designing and/or making.

In terms of 'teaching and problem solving', teachers (can) only give you the starting point (the brief). However, many saw this as a 'strength' and of value in terms of

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[2] Schools Council (1981) Modular Courses in Technology: Problem Solving: Teacher's Guide, Edinburgh: Oliver & Boyd in association with the National Centre for School Technology.
Schools Council (1981) Modular Courses in Technology: Problem Solving: Workbook, Edinburgh: Oliver & Boyd in association with the National Centre for School Technology.
[3] Schools Council (1974) Design and Craft Education Project: Education Through Design and Craft, Materials and Design, London: Edward Arnold.

learning more, and one considered, "but you realise they leave you to do it for a reason". Another considered that, "They don't say: this is how to solve problems and this is what you're going to do..." In fact, it was expressed that, "...if they did tell you, you wouldn't be problem solving... otherwise, no point in giving the problem in the first place!". In addition, there was a realisation that this is to be expected in design and technology as opposed to, for example, mathematics (maths is learning about it, design and technology is common sense and using knowledge).

Those who did consider that the teachers teach it focused on and interpreted it as:

- showing and demonstrating how to do things (e.g., practical processes);
- providing constraints and guidelines;
- providing help, as a one-to-one process;
- giving more information;
- giving more clues;
- helping you make it;
- doing it for you when you ask for help;
- giving you an equivalent scenario in another related subject to transfer across.

In response to the question of whether they thought that teachers actually teach you how to solve problems in D&T, one replied, "not how to - but just tell you what to do".

Another replied, "Yes, I think they teach you the skills to be able to learn... rather than actually saying: here's the answer to your problem... I think... these are the skills... these are the things you've got to look at, the points that you've got to investigate to find out which bits are actually the problem".

'Positive feelings outweigh the negative, in terms of the justification of problem solving in D&T!'

Some interesting and pertinent issues were raised by the pupils through the greater proportion of positive statements made (as opposed to the lower number of negative statements). Many simply said that it was a good thing, although, a number of them were, in effect, talking about designing and/or making.

Examples of the positive statements included:

- it's important to be able to know how to problem solve, to be able to do it and be in a position to apply it later – it makes the (manufactured) article better because you think about it more and therefore are more aware when making artefacts, and it enables you to improve things or fix things;
- it's valuable - even if it doesn't work it is still valuable (unlike mathematics);
- it's a good skill to learn;
- they enjoy it - it is fun 'as a game';
- it's good that it is a challenge and is hard;
- it helps you learn more - you learn more - to understand it more;
- it gets you thinking more for yourself;
- it enables you to compromise;

- it makes your actual mind work, in preparation for progression to more complex problem solving;
- it is more individual to you and independent of the teacher, and therefore develops independence;
- it is interesting how people find answers in different ways;
- the open-endedness is good - no one answer - no wrong answer - our ideas;
- it's good to evaluate it.

Negative feelings and expressed difficulties were couched in terms of too much time spent on it with the consequence of it becoming a boring drawn-out process, leading to frustration.

Some 'did not like it', due to:

- lack of relevance of projects (and use of inappropriate materials);
- a preference for making things (rather than thinking);
- needing an idea to start with;
- frustration when they only give you clues;
- if it's hard I get fed up – it involves difficult/tricky processes;
- not finishing projects;
- too much drawing;
- (it is done) because they want to bore us.

Some further aspects were associated with worries over taking risks and getting things wrong, linked to not being able to make what you draw/design.

One pupil could not see the justification for it in design and technology, and another considered problem solving harder to do in technology.

'Interesting and pertinent characteristics identified'

A range of pertinent characteristics of problem solving, as perceived by the pupils, were mentioned, such as:

- it is a 'double practical' - you work it out, make it, and go back to working it out again if necessary, etc;
- they are bigger, longer problems in design and technology, with more aspects;
- you put problems into practice in design and technology, and you apply it;
- it's a trial-and-error thing, and you learn by doing things wrong in technology;
- it needs more thinking;
- you can't cheat, in mathematics you can use a calculator!;
- it's a series of ongoing problems leading to the whole;
- there is more freedom, and it is more open;
- you could evaluate it after trying to make it once, otherwise it becomes frustrating;
- in technology problem solving is easier;
- it is harder when you can't do it with your hands.

'Uncertainties over what it is'

Initial responses to the questions concerning problem solving often included aspects of uncertainty, such as:

- what do you mean by it/problem solving?;
- I don't know what you mean;
- it depends on what it is;
- what sort of problem solving? - do you mean improving stuff?;
- which type of problem solving?

However, they did provide many perceptive comments which featured considerable levels of 'sophistication' about the merits of problem solving, which can be seen to link back to the previous category above. Also, most of these were of a positive nature, such as it being 'a challenge', despite the image generally portrayed by teachers.

Many of the concrete examples provided were of the nature of ongoing (transient) problems within their work, such as the response of it being:

- ongoing problems - not the whole problem as set in maths;

and different 'types' of problems were described, within the context of making, in terms of:

- correcting mistakes;

- shaping things;
- deciding on sizes, etc;
- accuracy;
- problems with equipment leading to things going wrong;
- deciding which equipment to use;
- technical problems;

or linked to the design process, such as:

- development or refinement of ideas so that they 'work';
- drawing ideas;
- designs;
- designing.

'Positive statements of transferability!'

In spite of no actual question on transferability, a number of pupils considered that you could:

- generally apply it to other situations;
- can transfer it to future situations;
- can transfer it to life situations;

and that:

- it is good for every subject so you really understand.

Also, it was considered useful for the future in regard to:

future jobs and employment (for example, a detective!);

starting a business;

DIY (Do it Yourself), therefore saving money;

fixing things (for example, electronics).

In terms of the relevance of projects to the future use of problem solving, one pupil questioned the relevance of the projects completed in school. However, another pupil realised that it is not the project that was important, but the process.

There is an apparent dichotomy emerging from the pupils' responses. We see a positive view of generic problem solving within design and technology while specific examples of a transient nature are cited. Overall, there is a sense of appreciating the importance of experiencing problem solving in design and technology in order that it can enable pupils to be good generic problem-solvers later in life.

Experts

'No overt sense of teachers teaching problem solving'

The majority of 'experts' did not acknowledge teachers actually teaching pupils how to solve problems in their own right (not overtly, and, not actually teaching it). Most alluded to it occurring within the context of designing and the design process, for instance:

- but we drop the designing process on them when they haven't got the maturity or background;
- we say: right, three or four ideas, but don't have procedures for solving problems taught to them;
- I don't see/hear teachers saying: well, there are problems which are open-ended and problems which are closed-ended for a variety of situations...;
- There is the process of solving a problem, but they don't have procedures for solving problems taught to them – the 'nearest' is designing... think of three ideas, compare them, etc.

When they spoke of any techniques these tended to be associated with the design process, in addition to it being taught through:

- encouraging questioning;
- pointing them in the direction;
- providing opportunities for problem solving;

- providing a range of techniques;
- demystifying it.

Those who did consider that teachers do actually teach problem solving, seemed to be 'at a loss' to explain how (for example, "problem-solving techniques - yes"). However, one person considered that there are skills to be taught and saw it as teaching critical and creative thinking, linking it to the Design and Craft Education Project model based on divergent and convergent thinking (as featured earlier, refer to figure 3), and de Bono's CORT thinking skills programme (refer to appendix B). But again, he/she did not necessarily specify how the teaching would occur.

One response was based on the fact that:

- you solve problems through design strategies, and therefore it is a 'non-question' (of whether teachers actually teach problem solving).

One of the experts (a national figure within the design and technology world) responded:

- I've not really thought about problem solving skills;

and subsequently:

- I've never consciously thought about problem solving all the time I was involved, as a teacher, with the kids designing, and, therefore, I am not sure that such an exploration is helpful.

This was associated with the consideration that:

- It would be difficult to do in isolation, and if done in a covert way would detract from the flow of the design process, which provides the context for pupils to solve problems for themselves;

which can be seen to link to:

- as problem solving, it would become contrived and too much teacher-led;
- ... but when they come to a barrier... I think you're right in that kids can go beyond that barrier... I'm just not sure that it's helpful if there are sets of things that are kind of given to them as... as right, well this is what you do now... I think it is much more useful if they actually evolve that themselves...;
- you can't apply a mechanistic thing to design problems;
- teachers see it mechanistically.

'Recognition of need for more understanding of teaching and learning within D&T'

One of the advisers considered that:

- we have not really got to grips with the different ways that children think and learn;

and:

- we've got to look at teaching and ways learning takes place (which was linked to consideration of learning and thinking styles of individual pupils).

Further related comments regarding 'learning and problem solving' included:

- there are, even in a generic sense, a set of sub-skills that we could work on with children in order to develop their analytical skills;
- a problem solving approach to smaller things helps them experience things in a way which makes them accessible and usable;
- there must be a hierarchy - we must all consider when planning activities for children (but the respondent did not elaborate what this might be);
- I think their metacognition would be pretty low on this;
- in schools they're not inspired... they're just put off;
- children find the cognitive challenge of designing extremely difficult;
- tightly taught skills and constrained choice of materials leads to better problem solving, and, conversely, 'loosely' taught skills and wide choice of materials leads to poorer problem solving;
- ... I as a teacher, a kind of teacher, still wrestle with putting together an educational experience where children take on board knowledge and understanding about the nature of materials and the way they can combine this, and, at the same time, be encouraged to produce ambitious solutions to problems using those materials...;
- in key stage 3, teachers have less overall insight into issues associated with experiential learning considerations.

'Lack of consensus over characteristics of problem solving'

It was noticeable that, even as groups of 'experts' within the field, there was an uncertainty over what problem solving is, as exemplified by:

- do we all - what do we think problem solving actually is?... because if we've all got different perceptions of it... it's back to what do you mean by it;

and,

- actually it's testing in reality against expectations;
- it's about generic skills... it's about life skills;

'Problem solving particular to D&T'

When 'pushed', considerations of 'problem solving' particular to D&T emerged, such as:

- it is more about <u>resolving</u> a problem - as opposed to <u>solving</u> a problem;
- it is thinking through with the use of materials;
- it is testing in reality against expectations... will it work or not?;
- it is where there is an outcome that can be measured (visible) - in terms of shades of success or failure - not solved as such - just a suggested solution;
- it is alternative ways of finding solutions - for comparison;

- in D&T it is more tenuous and vague - as opposed to maths where there is an answer.

In addition, it was felt by one of the experts that the (structures) bridge-project was a design exercise involving little problems, and therefore it had problem solving within it.

Interestingly, the notion of a 'problem solving conversation' was promulgated – where, within the context of pupils designing, the teacher poses questions and then leaves them to get on and subsequently returns to see how they develop their thinking.

'Relationship between designing, creativity and problem solving'

Linked to the emphasis on designing and the design process in design and technology:

- designing: might be producing something new, trying out an idea to test it, a fictitious design cycle thing (but it 'creates' links to creativity);
- quite a lot of designing has got nothing to do with problem solving... you're not setting out to solve a problem, you're setting out to create something that is really exciting;
- designing is the big task, and therefore of a higher order than problem solving, which is smaller tasks and of a lower order;

and, conversely:

- (it might be semantics, but) problem solving is of a higher order... (but with acknowledgement of the fact that they get confused);
- designing strategies = problem solving strategies.
- designing must include creativity and problem solving, but not necessarily the other way round;
- good designing may include creativity, but won't necessarily;
- creativity exists as a feature of problem solving;
- with creativity you can have that leap, that imaginative jump, and problem solving can be lots of small steps.

Once again, it is evident that the design process dominated responses from the two groups of experts. It was generally considered that problem solving would occur as a result of involvement in the design process and the manufacture of artefacts, and that teaching should focus on processes associated with such a design process. However, those who focused more on relationships between design and technology and general educational issues considered problem solving as being distinct from the design process. Specific reference was made to the influence of the model of divergent and convergent thinking from the Design and Craft Education Project (in common with some of the teachers) with links made to 'lateral' and 'critical' thinking and creativity.

Overall Themes from Data

1. Overall lack of clarity over what problem solving is.

2. An uncertainty about problem solving within the context of design-based design and technology from the perspective of teachers and experts, allied to the domination of the design process in considerations associated with pedagogy.

3. The questioning of the legitimacy of problem solving within design-based design and technology, particularly from teachers.

4. A positive sense of the notion of problem solving within design and technology expressed by pupils, who often responded in an informative mature manner about the purpose of problem solving (in a generic sense) as opposed to the more negative consideration on their behalf expressed by teachers.

5. Uncertainty about whether you can 'teach' problem solving from all three groups.

6. Relative lack of pedagogical considerations in terms of cognitive psychology and 'cognitive modelling' references from teachers, and, to a lesser extent, experts.

7. Relative lack of pedagogical considerations in terms of consideration of teaching and learning issues associated with learning and thinking styles expressed particularly by experts.

8. Simplistic notions of differentiation and progression, in terms of any hierarchical structure of problem solving.

9. Lack of 'information' for teachers regarding issues associated with problem solving within design and technology - both in terms of ITT (Initial Teacher Training) and INSET (in-service education of teachers).

10. An overall sense of 'mixed-agendas' in operation between teachers and pupils regarding teaching involving problem solving within design and technology.

11. The lack of 'expression of purpose' in teaching involving problem solving in design and technology, allied to the need for aims and objectives to be expressed more explicitly/overtly in terms of teaching involving problem solving in design and technology.

Chapter 6 Summary, Conclusions and Recommendations

Summary

The purpose of this study was to investigate perceived efficacy of design and technology, for pupils between eleven and fourteen, from a problem solving perspective. This was conducted with the purpose of distinguishing between documented 'evidence', claims and the experience of those directly involved in teaching and learning. The research was based on qualitative approaches, where emergent 'grounded theory' was established, based on 'establishing meaning from what people say', within the context of peer review of experience and opinion.

The literature review indicated that, while problem solving has been acknowledged as important in relation to the development of individuals within an ever-changing technological society, it remained implicit but vague within the dominant design and realisation dimension in design and technology. Considerable overlap exists between developments associated with 'designing', 'creativity' and 'problem solving' and yet the focus within design and technology has been on the acceptance of 'the design process' as 'the approach' to pedagogical consideration. The UK perspective focused on the design process, despite earlier developments associated with concepts such as creativity, while that from the US focused more on pedagogical considerations associated with models of problem solving.

Focus group interviewing was selected as a way of determining the 'state of play' from the perspective of teachers and pupils in a sample of twelve schools, as well as two groups of 'experts' within the field of design and technology education. Issues that emerged from the review of literature formed the basis of the 'questioning route' within the sessions conducted in schools and with the groups of experts. The 26 group sessions were fully transcribed and enabled data analysis to be carried out based on an iterative 'constant comparative method'. Such an approach, supplemented by cognitive mapping, created sets of emergent 'meanings' in terms of experiences, opinions, thoughts and concepts (as a result of the process of inductive category coding and simultaneous comparison).

Although such an approach to data analysis would enable tracking to occur, no obvious patterns emerged to distinguish any correlation of 'classification' or 'categorisation' of teachers, pupils or experts, such as considerations of problem solving and success rates at exams. Rather, the sample of schools and experts were utilised as a representative cross-section which included variation within it.

Conclusions

The results of the study encompass a series of issues based on the collective experience and opinion of teachers and pupils within the sample schools in addition to design and technology educators in local and national contexts. Such emergent issues were considered in conjunction with the review of literature previously conducted. The results represent 'actual generalisation' within the research sample as well as 'potential generalisation' beyond these schools as a result of the multiplicity of data (Anderson, 1990).

Broadly speaking:

Teachers

1. find problem solving ill-defined and confusing;
2. agree that problem solving is important;
3. feel dissatisfied with what they do in terms of such a focus;
4. want more in-service training and support regarding problem solving.

Students

1. confirm points 1 to 3 above;
2. want more and better problem solving;
3. want better links with the rest of design and technology.

Experts

1. confirm issues expressed by teachers and pupils;
2. do not, themselves, offer definitive models of problem solving.

Clearly, the development of the subject of design and technology has been dominated by the influence of 'the design process'. The design process, as accepted within the sample schools, and, more broadly, England and Wales, dominates thinking associated with any pedagogical consideration about design and technology, particularly at key stage 3. As such the subject of design and technology remains 'problem-based', as opposed to 'problem solving'; or to put it another way, problems are presented to pupils as the starting point for design tasks. Some would consider such an approach within design and technology to be aligned to 'problem resolving' as opposed to 'problem solving'.

It is evident that the design and technology community within secondary schools generally operates in an insular way. Issues associated with the teaching of the subject centre very much on pupils handling the design process and the manufacture of artefacts, to the detriment of broader educational issues. Those who did respond within a broader educational framework were either 'reflective practitioners' (as individuals, often 'isolated' within their departments) or were influenced to varying degrees from outside the subject, as was the case with a department having participated in a training session based on 'thinking within the curriculum'.

There is a need for a better and more effective pedagogical framework for teachers to operate within, to provide a more desirable balance between 'teaching and learning of design and technology' and contemporary and future educational purpose. Dodd (1978) alluded to the influence of swings between technical expertise and free expression in his historical analysis of the development of the subject up to the 1970s, and more recently those involved in the Problem Solving in Technology Education (PSTE) research project have reinforced such concern in that:

> Educational practice swings periodically between knowledge-orientated and general process- or skill-orientated teaching, with an accompanying de-emphasis on subject matter knowledge. This is precisely the situation in which technology education finds itself at present.
>
> (Hennessy, 1993: 29)

An American perspective on research conducted by McCormick and colleagues such as Hennessy, '...indicates that, even with the requisite content knowledge, teachers may not be able to achieve their instructional goals unless they are also highly skilled in classroom management' (Raizen, Sellwood, Todd & Vickers, 1995: 129). However, it is acknowledged that such research indicates, '...teaching intellectual content while also engaging students in design tasks is not easy' (ibid: 129).

Within the contemporary scene we are reminded about justifications for the development of teaching and learning of design and technology:

> ...while the underlying economic structures of society are undergoing a dramatic transformation, our educational structures are lagging behind. The

> challenge of delivering an expanding set of skills and competencies is being partially met by the creation of a new lifelong learning infrastructure. However, innovations in lifelong learning continue to exist on the fringes of our education system. The dominant educational paradigm still focuses on what students know, rather than how they use that knowledge.
>
> (Seltzer & Bentley, 1999: 9)

There is much for teachers to focus on to build up pupils' problem solving capability within design and technology. Data analysis indicated a positive desire for this allied to the recognition of the merit of such an approach. Many pupils independently drew attention to the potential transference of abilities to solve problems to their needs later on in life. However, existing examples of problem solving cited by pupils focused on transient problems rather than 'true problem solving' (although they expressed support for generic problem solving). The teaching of design and technology is dominated by the design process, which, while being about the solving of problems is not necessarily problem solving. In other words, pupils might be able to solve specific problems without becoming good problem solvers. Therefore, a realistic way forward would be the adoption of generic problem solving strategies within a design-process dominated curriculum model. As such, links would need to be developed beyond the existing relatively narrow pedagogical model. For instance, teaching strategies ought to be considered to promote the full range of cognitive demand, as exemplified by the following model in America:

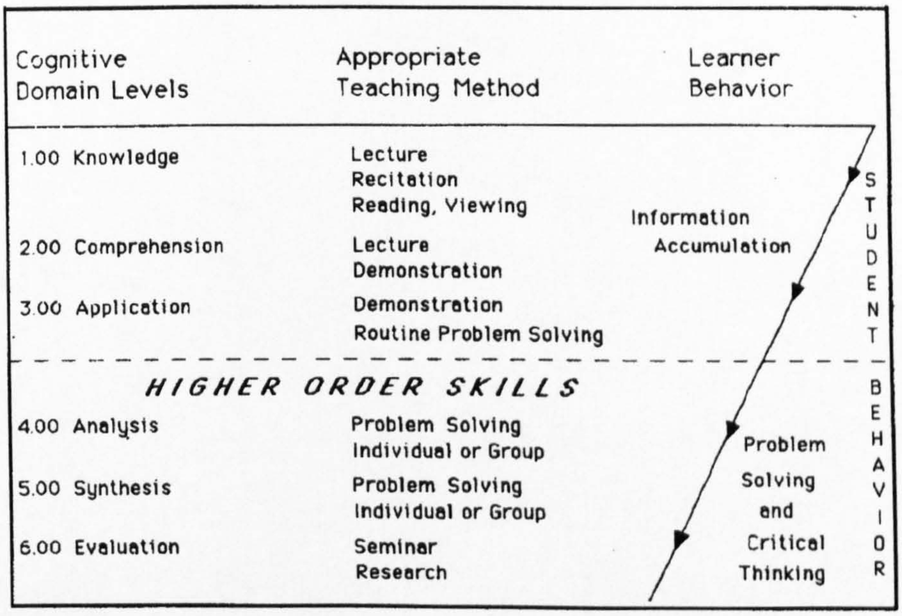

FIGURE 1
Relationships of teaching methods, cognitive domain levels and problem solving.

Figure 23. Teaching Strategies from an American Perspective (Anderson, 1989: 4).

Most of the preventive issues emerging out of the interviews, focused on a lack of sufficient time due to pressures of manufacturing skills and processes, as well as pedagogical principles directly associated with problem solving approaches. Therefore, a better balance is needed for individual teachers and/or departments based on the following models:

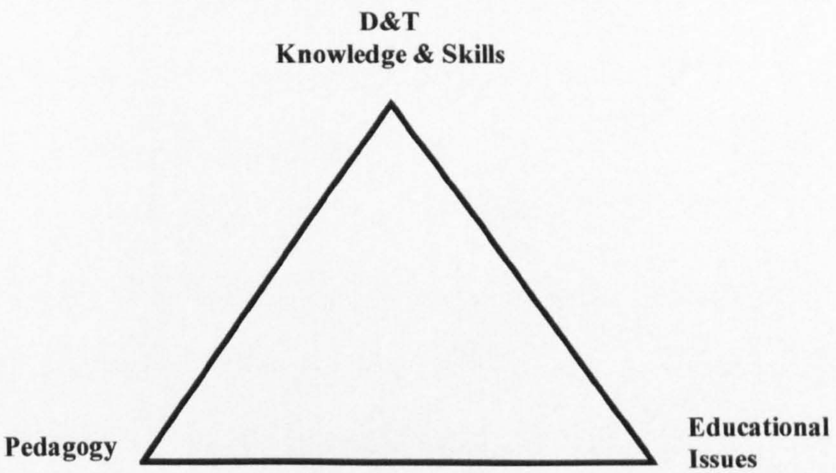

Figure 24. Pedagogical Model 1.

or:

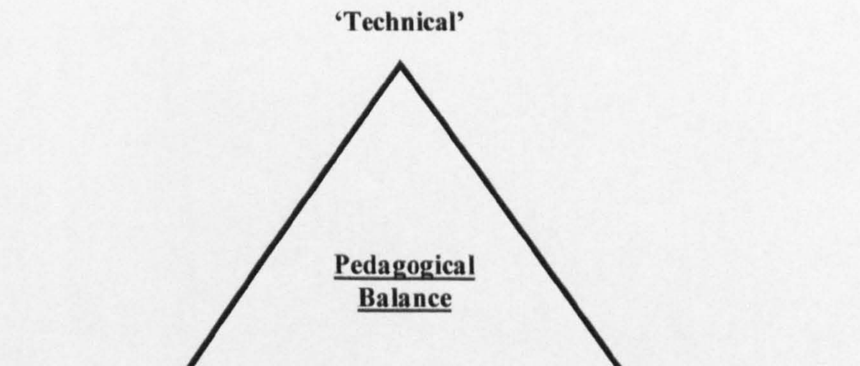

Figure 25. Pedagogical Model 2.

Such 'pedagogical balance' would enhance the curriculum and satisfy the need for a greater focus on of 'ways of learning and knowing' (Claxton, 1999). Specific examples of assistance to teachers and pupils might involve a greater awareness of concepts such as learning styles (Honey & Mumford, 1995), thinking styles (Sternberg, 1997) and cognitive styles (Riding & Cheema, 1991). Also, it might be timely to reconsider the tasks presented to pupils in terms of intrinsic and extrinsic motivation, within an environment more cognisant of creativity.

In a relatively simple sense, there is a need for a modification of pedagogical issues associated with consideration of any hierarchical structure in terms of progression and differentiation, as indicated by the following model:

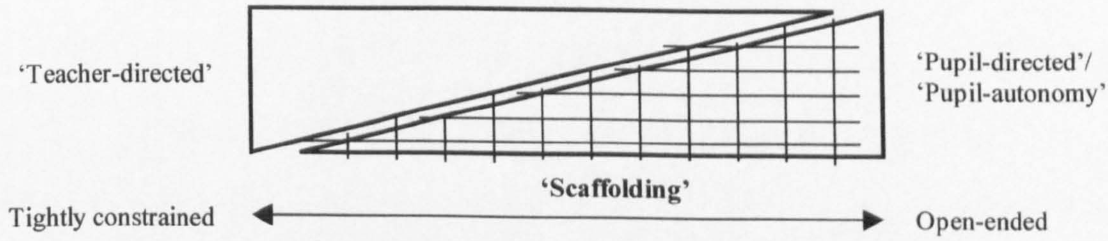

Figure 26. Pedagogical Model 3
(developed from a model presented by Kimbell, Stables & Green, 1996).

Such an approach would give greater regard to cognitive psychology. For example, the work of Vygotski (1978) and Bruner (1966; 1977; 1990) and principles associated with 'scaffolding' and the legitimate role of intervention and mediation (Feuerstein et al, 1981) in such teaching and learning, would help in 'promoting' and 'legitimising' the real cognitive demand placed on pupils in such contexts, without the danger of seemingly diminishing the validity of the subject as far as 'critics' are concerned.

Teachers have expressed a desire for more in-service training provision, and if such a demand was acknowledged then balance would still need to be redressed in providing a greater focus on pedagogical issues as well as insight into and experience of 'new technologies'. For new recruits to the teaching of design and technology, research conducted at the turn of the century indicates a real problem associated with negative views and attitudes held by final year undergraduates. They characterised teaching in terms of, '...lacking variety, professional freedom and creativity' (Kimbell & Miller, 2000: 1).

Recommendations

Methods for achieving a better balance of emphasis between 'processes' and 'outcomes' need to be considered. However, such approaches need to build on current good practice within the subject, without appearing to create a burdensome addition to the existing breadth of subject demand.

If it is accepted that the design process should involve resolving problems, then generic problem solving approaches could be 'grafted' onto such a model, to effectively improve the relationship between practice in design and technology and the desire for pupils' development as problem solvers within the whole curriculum. For instance, the latest version of the national curriculum gives greater acknowledgement of, 'the contribution of design and technology to the development of language, numeracy, ICT, key skills, creativity and innovation and thinking skills' (Davies, 2000: 166). An aspect such as thinking skills could feature as a focus for pedagogical development within existing approaches to the setting of problems for pupils to resolve within design and technology. A potential vehicle for such development and improved awareness lies within the scheme of work[1] produced to support the latest version of the national curriculum. For example, the connection between thinking skills and problem solving could be formalised and utilised to indicate to teachers how differing approaches and abilities lead to contrasting outcomes in projects featured within the scheme of work. Such a connection would correspond to the one effectively promoted by the government in its current web link from the Standards Site[2] to a DfEE commissioned report on thinking skills (McGuiness, 1999) which includes reference to problem solving. The use of such exemplars would serve to raise teachers' awareness of corresponding pedagogical issues which could promote further consideration of issues raised within the scope of this study.

[1] QCA (Qualifications and Curriculum Authority) (2000) D&T: A scheme of work for key stage 3: Teacher's Guide (NC 2000), London: QCA. Also found at: http://www.standards.dfee.gov.uk/schemes2/secondary_dt/teachers_guide/ - web site visited 19/03/2001.
[2] The Standards Site is a government web site found at: http://www.standards.dfee.gov.uk - web site visited 19/03/2001. It is an on-line service for teachers in England managed by the Standards and Effectiveness Unit (SEU) providing guidance and tools to help schools improve effectiveness, raise standards and reduce workload.

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Appendix A

Examples of Creativity Programmes

Such programmes were:

Productive-Thinking Programme which was aimed at increasing the general problem-solving skills of 5th and 6th grade pupils through practice in solving mystery and detective stories.

Inquiry Training which was designed to teach problem solving in science by asking pupils to react to a filmed or live demonstration.

Thinking Creatively which was based on a workbook in the form of a humorous discussion among several cartoon characters.

Myers-Torrance Ideas Books which consisted of workbooks for elementary pupils and involved practice in solving creativity problems.

Purdue Creativity Programme which was set of tape-recordings with printed exercises designed to foster divergent thinking in 4th grade pupils.

Parnes Programme which was based on Osborn's brainstorming techniques.

Appendix B

Examples of Programmes for 'Developing Minds'
(Costa, 1991b)

Costa (1991b) provides a thorough review of programmes associated with 'developing minds', and it is interesting to note the number of them associated with problem solving:

SOI (Structure of the Intellect), based on Guilford's Structure of Intellect theory, aimed at equipping pupils (and adults) with the necessary intellectual skills to learn subject matter and critical thinking through the use of two and three-dimensional materials prescribed for them based on a diagnostic test, with computer software providing analyses and prescriptions.

Instrumental Enrichment, developed by Reuven Feuerstein, aimed at developing pupils' thinking and problem-solving abilities in order to become autonomous learners, through the use of paper-and-pencil 'instruments' for insight to bring about transfer of learning, with the teacher acting as a 'mediating agent'.

Expand Your Thinking, based on the work of Albert Upton, aimed at training pupils to use graphic organisers as tools for applying thinking skills to content through working in cooperative pairs, through the use of thinking (cognitive) maps.

CoRT Thinking Programme (Cognitive Research Trust), developed by Edward de Bono, aimed at teaching thinking skills useful to everyone in or out of school, through practising 'operations' and following 'lesson notes' associated with lateral thinking.

IMPACT (Improving Minimal Proficiencies by Activating Critical Thinking), developed by S. Lee Wincour, aimed at improving performance in content areas by facilitating acquisition of higher-level thinking skills, through learning activities that include critical thinking components infused into content area lessons.

Future Problem Solving, developed by Torrance and based on the work of Osborn and Parnes, aimed at developing creative problem-solving skills while learning about the future, through teams of four following a multiple-step problem-solving process: gathering information, brainstorming problems from a given situation, identifying the major underlying problem, brainstorming solutions, selecting criteria for evaluating solutions, and evaluating solutions to determine the best one.

Guided Design, developed Charles Wales with Robert Stager and Anne Nardi, aimed at teaching pupils to use the process of decision making as they apply the subject matter they are learning, through the use of the 'complete' decision-making process modelled step-by-step in slow motion, verbally or with printed instruction-feed-back materials.

Odyssey, developed by a team of researchers based at Harvard University and the Venezuelan Ministry of Education, aimed at teaching a broad range of generalisable thinking skills, through emphasis on discussion and student engagement in problem solving, reasoning, decision making and creative activities, with the use of some paper-and-pencil exercises.

CPS (Creative Problem Solving), developed by Parnes, and based on the work of Osborn, aimed at developing abilities and attitudes necessary for creative learning, problem sensing and problem solving, through the use of activity sheets for practice activities and teacher's operating from an instructor's handbook, or alternate independent self- or group-study and practice, with an overall emphasis on transfer of learning.

HOTS (Higher-Order Thinking Skills), developed by Stanley Pogrow, based on cognitive psychology theories of organisation of information in the brain, aimed at developing higher-order thinking skills to improve basic skill achievemnt, problem-solving ability and social confidence, through the use of computers, together with specially designed curricular materials and Socraric teaching strategies.

Creative Learning and Problem Solving, developed by Scott Isaksen and Donald Treffinger, based on the work of Osborn, Parnes, Noller and others, aimed at the development of strategies for problem solving, integrating both creative and critical thinking, through being taught guidelines and thinking 'tools' or techniques for generating and analysing ideas, applied as part of a systematic process for dealing with open-ended or ill-structured challenges, leading to applications in many structured situations and working autonomously (independently or in groups) to identify and deal effectively with real problems and challenges.

Young Think, Just Think and Stretch Think Programmes, developed by Sydney Billing Tyler, aimed at teaching thinking, through the use of thinking programmes often involving design-based activity to reinforce reading and writing.

CCYC (Cognitive Curriculum for Young Children), developed by H. Carl Haywood, aimed at helping young children acquire, generate and elaborate systematic processes of perceiving, thinking, learning and problem solving, through activities to stimulate metacognition, and about generating, applying and evaluating appropriate learning and problem-solving strategies.

In addition, there are a number of further programmes concerned more with 'thinking' and 'learning to learn' such as: *Philosophy for Children*; *LTL (Learning to Learn)*;*Thinking to Write*; *Tactics for Thinking*; *Connections*; *Talents Unlimited*; *Intelligence Applied*; *The Touchstone Project*; *Thinking to Learn*; and, *DTS (Developing Thinking Skills)*.

Appendix C

Somerset Thinking Skills Course (1988)
(Taken from unacknowledged student seminar handout (1989) - derived from a Somerset Thinking Skills INSET course (date unknown - not acknowledged on handout))

This programme became known as the Somerset Thinking Skills Course. It is intended to be open-ended and becomes progressively more difficult by making the problems or contexts:

1. More abstract (removed from concrete experiences with a greater use of symbolism; or,
2. Containing greater amounts of information.

- There is a focus on problem solving which aims to:
- Reduce impulsivity;
- Develop self-esteem;
- Improve oracy skills (by);
- Working independently or in small groups -
- Enabling the teacher to establish the right kind of working environment for
- learning, or a term that is frequently used - 'learning to learn'.

It features the following skills:

1. Working precisely and accurately.
2. Paying close attention to detail.
3. Recognising and interpreting implicit instruction.
4. Reading and interpreting explicit instructions.
5. Recognising and interpreting clues and reference points.
6. Scanning and focusing.
7. Searching systematically.
8. Distinguishing relevant from irrelevant information.
9. Labelling, coding and abbreviating.
10. Understanding universal codes, symbols and conventions in deciphering and recording information in many modes.
11. Creating a clear mental image of objects and events.
12. Giving clear instructions appropriate to the listener.
13. Describing, comparing and clarifying.
14. Establishing patterns and relationships.
15. Handling several sources of information simultaneously.

These skills are set within the context of the following pupil activities:

1. Stimulus activities, which provoke discussion and connections across different areas.
2. Artificial activities, many of which are abstract, involving a range of tasks that expose the need for certain cognitive resources, vocabulary, skills and approaches, and provide an opportunity for demonstrating their importance and application in everyday life.
3. More naturalistic tasks offering opportunities for applying cognitive resources already acquired to a wide range of more familiar everyday problems.

The following working model is presented within this course:

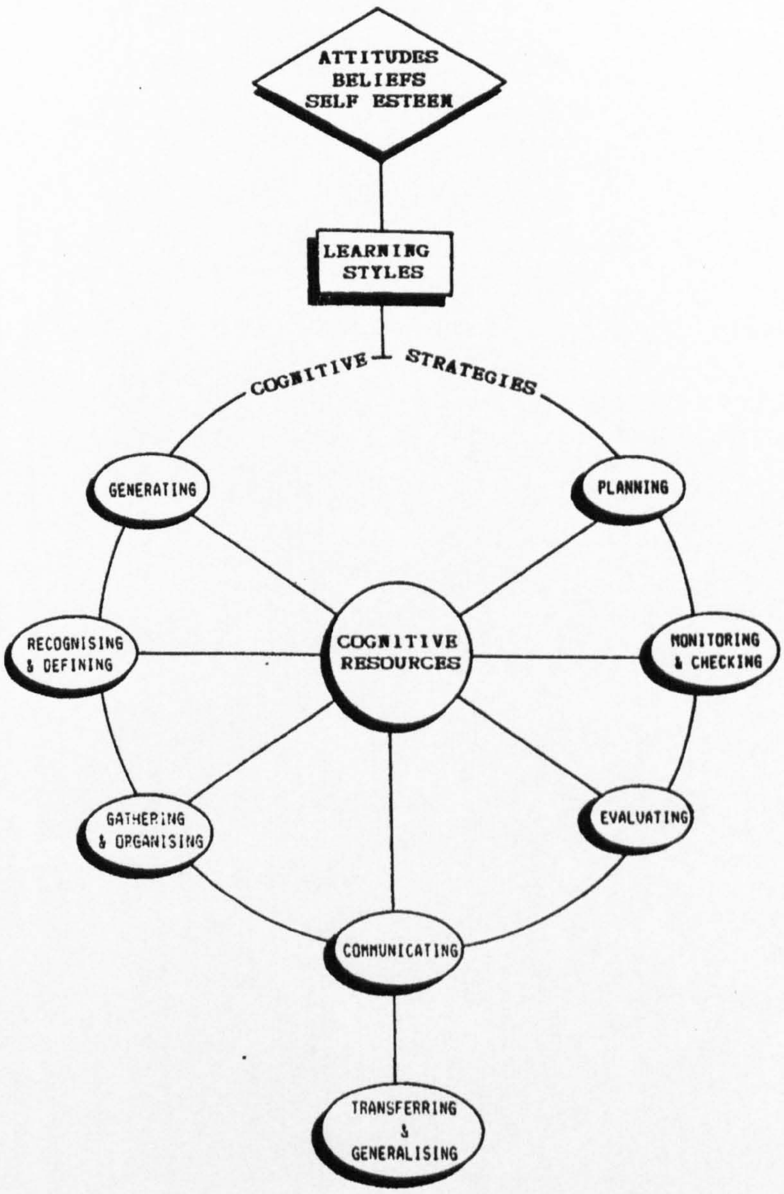
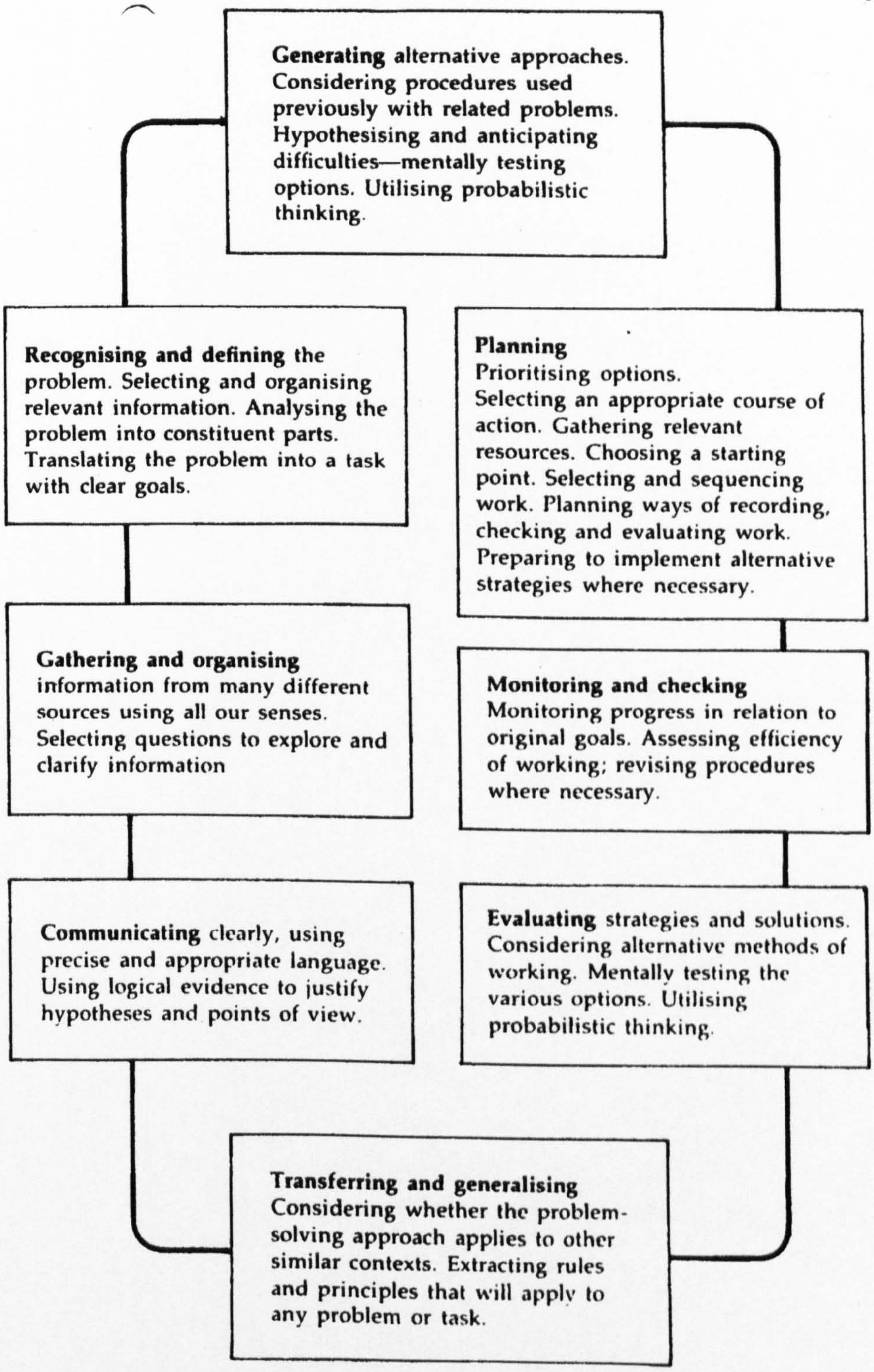


FIGURE 2.2 STSC WORKING MODEL

Backed up with the following further diagram:



(Figure number unknown - not included on source)

Appendix D

References to Problem Solving in National Curriculum Documents
(Murphy, Hennesy & McCormick, 1995: 44)

Table 3.1: A tally of references to problem solving in National Curriculum documents using categories derived from the literature

Date	Document	Design as Problem solving: As a Process	As Problems and Solutions	General problem solving	Problem-based Learning	Emergent problems	Total
April 1988	Terms of Reference (DES/WO, 1989, p. 93)	0	0	1	0	0	1
Nov. 1988	D&T Working Group Interim Report (DES/WO, 1988, pp. 6, 9, 10, 13-15)	2	2	1	0	2	7
June 1989	D&T Working Group Final Report (DES/WO 1989, pp. 7, 19, 20, 43, 44, 50, 60, 65, 82, 87)	6	1	0	0	5	12
March 1990	Technology Order [No. 1] (DES/WO 1990, pp. 4, 11, 12-14, 24, 31, 41)	2	3	0	0	5	10
March 1990	Non-Statutory Guidance: England (NCC, 1990, pp. 1, A1, A2, A6, B3, C6, C10)	2	4	1	0	0	7
May 1990	NSG - Wales (CWW, 1990, pp. A2, A6, A9, A11, B3, B13)	2	2	1	1	0	6
June-Dec. 1992	HMI Consultation (DFE/WO, 1992, pp. 48 & 49)	1	1	0	0	0	2
Dec. 1992	Revision Proposals [No. 1] (DFE/WO 1992, pp. 25, 29, 40)	1	0	0	0	1	2
Sept. 1993	Revision Proposals [No. 2] (NCC, 1993, pp. 31-33, 36, 38)	3*	0	0	0	2*	5
May 1994	Proposals for Revision [No. 3] (SCAA, 1994, p. 28)	1	0	0	0	0	1
Jan. 1995	Technology Order [No. 2] (DFE/WO 1995, pp. 4, 5, 7, 10, 11, 15, 16	0	0	0	0	2	2
1995	Guide to Good Practice (OFSTED/ DFE, 1995, pp. 11, 14, 15, 17, 18, 33)	1	2	0	1	3	7
1995	NSG KS3 (SCAA, 1995, p. 15)	0	0	0	0	1	1

* This ignores repeated mentions from 'Core' to 'Full' course.

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(Murphy, Hennesy & McCormick, 1995: 44)

Appendix E

National Curriculum Development Documentation

National Curriculum Development Documentation

Development of 'The Orders, Version 1'

- November 1988 - National Curriculum Design and Technology Working Group Interim Report.
- June 1989 - National Curriculum Design and Technology for ages 5 to 16, Proposals of the Secretary of State for education and Science and the Secretary for Wales.
- November 1989 - National Curriculum Council, Technology 5-16 in the National Curriculum, a report to the Secretary of State for Education and Science on the statutory consultation for attainment targets and programmes of study for technology.
- March 1990 - National Curriculum, Technology in the National Curriculum (The Orders).

Development of 'The Orders, Version 2'

- December 1992 - National Curriculum, Technology for ages 5 to 16 (1992), Proposals of the Secretary of State for Education and the Secretary of State for Wales.
- May 1993 - National Curriculum Council, Report on National Curriculum Council Consultation: Technology.
- July 1993 - The National Curriculum and its Assessment: Interim Report ('The Dearing Report').
- September 1993 - National Curriculum Council, Technology Programmes of Study and Attainment Targets: Recommendations of the National Curriculum Council: Technology.
- December 1993 - The national Curriculum and its Assessment: Final Report ('The Dearing Report').
- May 1994 - School Curriculum and Assessment Authority, Design and Technology in the National Curriculum: Draft Proposals.
- January 1995 - Design and Technology in the National Curriculum (The 'Revised Orders').
- 1995 - School Curriculum and Assessment Authority, An Introduction to the Revised National Curriculum.
- 1995 - School Curriculum and Assessment Authority, Key Stage 3 Design and Technology: The New Requirements.

Development of 'The Orders, Version 3'

- 1999 - Design and Technology: The National Curriculum for England (The Orders for 'Curriculum 2000').

Appendix F

Explanatory Letter for Schools - Regarding Nature of Research

xxxxx xxxxx
xxxxxxxxxxx School

Design and Technology Research Project – Peter Taylor, Middlesex University

This forms part of a series of research activities by a group at the university. Various researchers (teachers and lecturers) are developing aspects of Science and Technology within key stages 1, 2 or 3. This forms the basis of a Science and Technology Education Research Project (STERP) with support from other lecturers within the university.

This research by Peter Taylor is also leading towards the award of MPhil.

The title of the research is:

'An investigation into the nature of problem solving in design and technology at key stage 3'

A central aim is:

To investigate the nature of problem solving in design and technology at key stage 3 with special reference to the perceptions of teachers and pupils.

Associated objectives include:

To interview teachers in the sample schools to gain an insight into their awareness, and use, of problem-solving processes.

To interview pupils in the sample schools to gain an insight into their awareness, and use, of problem-solving processes.

It is envisaged that possible outcomes will be:

Original contributions towards the ongoing debate about the role of problem solving in design and technology linked to the development of national curriculum technology.

The development of principles that will inform:
- a) students training to be teachers of design and technology, and;
- b) existing teachers of design and technology.

Rationale for the methodology:

Part of my original intention is to gain an insight into 'typical' problem-solving activities in key stage 3 design and technology in a cohort of schools. This is seen as a way of providing the researcher (myself) with an initial 'snap-shot' to base further work on. The initial descriptive form of research is to elicit opinion and concerns about the 'subject matter' linked to definitions, models and constructs and to formulate relationships between 'official advice', theory and practice. This would necessitate research into official advice from sources such as recent and current reports and policy documents, theories drawn from the literature search, and practice exemplified by teachers.

In broad terms this part of the research concentrates on producing descriptive account of the practice based on a 'process-product' approach to looking at the relationship between classroom events and outcomes.

This approach lends itself to my intention of being able to analyse teaching situations. A considerable amount of my work will relate to interviews in a number of schools. It would seem that a potential danger associated with basing analysis on teaching concerns the ownership and interpretation of such situations. I will need to get objective opinions and be able to analyse genuine concerns. I therefore intend to utilise the notion of 'focus group' interviews which concentrate on the importance of evaluation.

Focus group interviewing necessitates the group of teachers or pupils to respond to a number (approximately 8) of open questions over a period of thirty to forty minutes. These are recorded for the direct purpose of the research and researcher. Any subsequent findings will be available to the participants for scrutiny.

Focus group interviewing was chosen as an appropriate method of obtaining relevant qualitative data. The interview procedures were considered and designed for group responses from teachers and pupils in the sample schools.

The open-ended focus group questions (the 'questioning route') are arranged in a natural, logical sequence:

> Open-ended questions allow the respondent to determine the direction of the response. These open-ended questions provide an opportunity for the respondent to answer from a variety of dimensions. The answer is not implied and the type or manner on their specific situation. These open-ended questions are particularly appropriate in the beginning of the focused interview, but they can be effectively used throughout the discussion. The major advantage of the open-ended question is that it reveals what is on the interviewee's mind. Toward the end of the group interview, it is often productive to limit the types of responses and bring greater focus to the answers by shifting to closed-ended questions.
>
> (Krueger, 1988: 60)

The questions are arranged in a focused sequence in the hope that they might seem logical to the participants. The procedure goes from the general to specific.

The basis for this research is that:

I have been particularly interested in determining the effectiveness of problem stating and problem solving and the relationships between teachers and pupils engaged in these processes. Part of this interest has been associated with the notion of progression and operational levels linked to pupils at key stage 3 working independently on open-ended design-based problem solving.

(Krueger, R. (1988) *Focus Groups: A practical guide for applied research*, Newbury Park, CA: Sage)

Many thanks

Peter Taylor - Middlesex University

Appendix G

Characteristics of the Sample Schools and Corresponding Design and Technology / Technology Departments

Characteristics of the Sample Schools and Corresponding Design and Technology/Technology Departments

School 1

This is a comprehensive school for girls of 11-19 in a north London 'inner-city' Local Education Authority (LEA) which also admits boys into the sixth form. The number of pupils (including boys in the sixth form) is approximately 830. Within the context of London, it has around the average percentage of pupils with statements of special needs (2%), as well as having an average proportion of pupils eligible for free school meals. The school is culturally, ethnically, linguistically and socially diverse.

An OFSTED inspection of the school carried out in 1995 reported, amongst the main findings, that the pupils receive a good quality of education. It went on to reflect that by the end of Key Stage 3 unmoderated teacher assessments show most 14 year olds achieving standards in the core subjects (English, mathematics and science) which are better than those achieved nationally, and GCSE and A-level results are, overall, better than those achieved nationally. Specifically, within design and technology, the standards of achievement in Key Stage 3 show the majority of pupils reaching national norms.

The department[1], as represented at the focus group session, comprised of:

The head of department - male, aged 33. He had been in teaching for a total of 7 years[2], of which 5 had been in the current school. His initial teacher training (ITT) had been based on a 2-year Post Graduate Certificate in Education (PGCE) design and technology course[3], with his initial degree being in economics. Prior to teaching, he had worked as a trainee accountant.

Design and technology teacher - female, aged 28. She had been in teaching for a total of 3 years, all of which had been in the current school. Her ITT had been based on a 2-year PGCE design and technology course, with her initial degree being in art/art history. Prior to teaching, she had worked within media and P.R. (personnel relations).

Design and technology teacher - female, aged 29. She was completing her initial year of teaching. Her ITT had been based on PGCE in art and design, with her initial degree being in interior design. Prior to teaching she had worked in interior and textile design.

School 2

This is a multi-ethnic mixed comprehensive school for pupils 11-19, with a current roll of approximately 1275, in a north London 'inner-city' LEA. Pupils are from a very wide range of social backgrounds, and eligibility for free school meals is well above the national average. Attainment on entry is about average for comprehensive schools. The

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[1] The group represented a strong identity as a 'CDT' department. The subsequent OFSTED report described there being a separate home economics department, and, interestingly, they did not seem to be represented within this forum.
[2] Number of years in teaching was in response to a question linked to a general notion of teaching.
[3] Number of years given in response to a question based on being a teacher of design and technology/technology or precursor of this subject.

school has identified 216 pupils with special educational needs of whom 39 have statements of special educational needs, mostly for learning difficulties.

An OFSTED inspection carried out in 1996 reported, amongst the main findings, that it is a good school with many strengths. At Key Stage 3, results in the core subjects are good, with some aspects above the national average. However, in some of the other subjects it was reported that the results were weaker. In design and technology it was recognised that there was evident strength in graphic and product design, while some reservations were expressed concerning the teaching of specific practical skills as well as the desired breadth of the subject.

The department[4], as represented at the focus group session, comprised of:

Design and technology teacher - male, aged 38. He had been in teaching for a total of 17 to 18 years, of which 9 had been in the current school. His ITT had been based on a Certificate of Education (Cert. Ed) in geography and environmental studies. Subsequently, he completed a one-year full-time conversion course for design and technology which took place about 8 years previous to the focus group session. Prior to teaching he had worked for a year within site surveying for architects.

Design and technology teacher - female, aged 32. She had been in teaching for a total of 4 years, all of which had been in the current school. She had recently acted as deputy head of department, and was going be acting head of department. Her ITT had been based on a one-year PGCE design and technology course, with her initial degree being in jewellery design. Prior to teaching she had spent two years as a manager of a production team in a design workshop.

Design and technology teacher - female, aged 32. She had been in teaching for a total of 4 years, all of which had been in the current school. She was going to be acting deputy head of department. Her ITT had been based on a one-year PGCE design and technology course, with her initial degree being in theatre design. Prior to teaching she had spent time in 'managerial positions'.

Design and technology teacher - male, aged 35. He had been involved in teaching for a year, in the current school. His ITT had been based on a PGCE design and technology course, with his initial degree being in theatre design. Prior to teaching as well as being a theatre designer, he had run workshops in youth theatre and operating as a freelance designer and model maker.

The head of department was, unfortunately, unable to attend the focus group session at this time.

School 3

This is a comprehensive school for boys of 11-19 in a north London 'inner-city' LEA. The number of pupils on roll is just over 1,000; with a wide range of ethnic, social, economic and language backgrounds represented in the intake. Over 60% come from a

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[4] The department reflected a strong bias towards 'CDT' although they were involved in work across the broader perspective of the subject. However, the school seemed to be uncommitted to the teaching of food at this stage.

variety of ethnic groups; few from professional backgrounds; over 50% are said to be eligible for free school meals; and 40% have English as their second language and eligible for 'Section 11' support. The school had previously been inspected on a number of occasions by HMI and reports published itemised a series of concerns associated with standards of achievement and behaviour. as well as the management of the school.

An OFSTED inspection carried out in 1994 reported, amongst its main findings, that there are many aspects of the work of the school which are satisfactory, with the pupils being offered a broad and balanced curriculum. It went on to point out that the results of the 1993 GCSE examinations show that the proportion of pupils achieving five or more grades A-C and five or more A-G was in the lowest 10% of all maintained schools in England. It further indicated that achievement is weakest in key Stage 3. Standards of achievement in relation to national norms were rated as average or above in 33% of lessons whilst standards judged against pupils' capabilities were satisfactory or better in 64% of lessons inspected. Specifically, within design and technology, the standards of achievement in Key Stage 3 are satisfactory in terms of capabilities with pupils acquiring varying degrees of coverage of the four Attainment Targets. From Year 7 pupils experience an increasing range of technological processes, constructional materials and design methodology. It was considered that there is scope for more consistent and greater achievement, especially in practical work, some of which is good.

The department[5], as represented at the focus group session, comprised of:

The head of department - male, aged 32. He had been in teaching for a total of 8 years, of which 5 had been in the current school. His ITT had been based on a three-year Bachelor of Education (B.Ed) course. Prior to teaching he had worked as an architectural technician.

The deputy head of department - female, aged 36. She had been in teaching for 4 years, all of which had been in the current school. Her ITT had been based on a PGCE in design and technology, with her initial degree being in fashion and textiles. Prior to teaching, she had been involved in designing and making special effects costumes for film, television and theatre.

Design and technology teacher - male, aged 26. This was his initial year of teaching. His ITT had been based on a PGCE in design and technology, with his initial degree being in electrical and electronic engineering. Prior to teaching he had been a joiner with a building firm.

School 4

This is a comprehensive school for girls of 11-19 in a north London 'inner-city' LEA which operates within a mixed gender consortium for 16-plus curriculum options. There are just under 1200 students on roll. The school's regular over-subscription by students seeking admission to Year 7 reflects its standing in the local community. Pupils come from a wide range of ethnic, religious, social and geographical backgrounds. Over 800

[5] The group reflected a department with an apparent strong bias to 'CDT', although they were involved in broader aspects such as textiles.

pupils are eligible for Section 11 support and over 600 speak English as an additional language. Approximately 40% are entitled to free school meals and the Special Needs Register includes approximately 150 pupils, with approximately 15 having statements of special needs.

An OFSTED inspection carried out in 1996 reported, amongst its main findings, that the attainment of pupils overall in the school is sound and around national expected levels. Specifically, within design and technology, the standards of achievement are generally in line with national expectations. At Key Stage 3 students have experience of designing and making artefacts using a full range of tools and materials. They develop good skills of designing and the quality of presentation and recording their work is at least sound and sometimes good. They have a good range of making skills using wood and metal as well as plastic, card and textile material.

The department[6], as represented at the focus group session, comprised of:

The head of department - female, aged 36. She had been in teaching for 15 years, of which 4 had been in the current school. Her ITT had been based on a 3 year B.Ed. course in CDT (Craft Design and Technology) and Art and Design.

Design and technology teacher - female, aged 42. She had been in teaching for 21 years, of which 12 had been in the current school. Her ITT had been based on a Cert. Ed in Textiles.

Design and technology teacher - female, aged 37. She had been in teaching for 4 years, all of which had been in the current school. Her ITT had been based on a PGCE design and technology course, with her initial degree being textile design and management. Prior to teaching she had been involved in a range of jobs associated with retail management.

Design and technology teacher - male, aged 29. He had been in teaching for 2 years in the current school. His ITT had been based on a PGCE design and technology course, with his initial degree being in three-dimensional ceramics design. Prior to teaching he had set up a ceramics studio and worked as an art technician.

Design and technology teacher - female, aged 33. She was completing her initial year of teaching in the current school. Her ITT had been based on a PGCE design and technology course, with her initial degree being in interior design. Prior to teaching she had worked in interior design.

Design and technology teacher - male, aged 29. He was completing his initial year of teaching in the current school. His ITT had been based on a PGCE design and technology course, with his initial degree being in materials science and engineering. Prior to teaching he had worked within materials research and mechanical engineering.

Design and technology student teacher ('beginning teacher') - female, aged 28. She was currently completing her PGCE ITT course in design and technology, with her initial

[6] The group represented a broad outlook on the breadth of subject taught, and appeared to operate as a cohesive group.

degree being in marketing. Prior to her ITT course she had been involved in fashion, furniture, exhibition and packaging design industries.

School 5

This is a grant maintained (GM) comprehensive school for boys and girls of 11-19 situated outside a conurbation to the north of London. The number of pupils is approximately 600. Pupils come from a range of social backgrounds, with about 20% receiving free school meals and about 16% from ethnic minorities, nearly all of who have English as their second language. There is a full range of academic ability, although in some years there are a high proportion of pupils with learning difficulties. There are approximately 20 pupils with statements of special educational need, including approximately 12 who are in a teaching support unit for the hearing impaired.

An OFSTED inspection carried out in 1995 reported, amongst its main findings, that the school has made much progress and has developed quickly as a grant maintained school. Acknowledged good qualities and strengths included the fact that the school encourages individuals at all levels to contribute and achieve, the behaviour of pupils and their relationships with one another and with adults are good, and the pleasant setting of the school provides a good learning environment. The overall standards of achievement match national averages; pupils make sound progress in the school. Within the school the better standards are at Key Stage 3 and for the average and more able. Pupils behave well and are usually attentive in lessons, and are generally well motivated and keen to learn. Younger pupils are eager to contribute their ideas and experiences to discussion. Specifically, within design and technology, standards of achievement for the majority of pupils, including those with special educational needs, are satisfactory or better in relation to national expectation and are commensurate with their abilities. It was noted that some of the projects in Key Stage 3 need modifying to allow pupils to contribute more of their own ideas, and to take a greater account of individual interests, gender and background. Design drawing is of a widely differing standard and pupils' coverage of the Programmes of Study in Key Stage 3 of the technology Order is constrained by the limited time available.

The department[7], as represented at the focus group session, comprised of:

The head of department (head of faculty) - male, aged 42. He had been in teaching for a total of 20 years, all of which had been in the current school. His ITT had been based on a 3-year Cert. Ed in craft design and technology.

Design and technology (food) teacher - female, aged 44. She had been in teaching for a total of 14 years, of which 4 had been in the current school. Her ITT had been based on a Teaching Certificate in domestic science.

Design and technology (information technology (IT)) teacher[8] - male, aged 43. He had been in teaching for a total of 20 years, of which 16 had been in the current school. His

[7] This group was based very much on a faculty arrangement with individual teachers having specific roles associated with their specialist subjects such as food, textiles and information technology (IT). For the purpose of relaying details regarding the focus group session the term department is used.
[8] This teacher expressed the fact that he was not a design and technology teacher.

ITT had been based on a PGCE integrated science course, with his initial degree being in zoology.

Design and technology (CDT) teacher - male, aged 37. He had been involved in teaching for a total of 14 years, all of which had been in the current school. His ITT had been based on a Cert. Ed. Prior to teaching he had worked within the retail trade for a couple of years.

Design and technology (textiles) teacher - female, aged approximately 50. She had been in teaching for a total of 28 years, of which 25 had been in the current school. Her ITT had been based on a Teachers Certificate in domestic subjects.

Design and technology student teacher ('beginning teacher') - female, aged 22. She was currently completing her 4-year B.Ed design and technology ITT course.

School 6

This is a comprehensive school for girls of 11-19 located in a very attractive rural setting in a socially favoured area. The number of pupils on roll is approximately 950. The school has a low proportion (approximately 6%) of pupils is entitled to free school meals and the proportion of pupils (approximately 3 pupils) for whom statements of special educational needs are maintained is well below the average for maintained schools in shire counties. There are few low achievers in the school's intake. As a single-sex school, pupils are drawn from a relatively wide catchment area.

An OFSTED inspection carried out in 1994 reported, amongst its main findings, that the standards of achievement at GCSE are very high with 76% of the pupils obtaining 5 or more subjects with grades A-C. The percentage of A or A* grades is over 18%, nearly twice the national average for the previous year. It was considered that the quality of learning has many good features, some outstanding aspects and very few shortcomings, and that teaching also has good features, some outstanding. Lessons are characterised by attentive and well-motivated pupils. Pupils have good attitudes towards their work. Specifically, within design and technology, achievement in relation to age and ability at Key Stages 3 and 4 as well as in the Sixth Form was good. Grades achieved in the GCSE examination exceeded the national norm in 1994. Pupils are successfully developing design and technology capability from Year 7 to Year 13. They have opportunities to realise their design in a wide range of materials including electronic components, using an increasing range of tools, techniques and equipment as they progress through the school. Pupils are generally able to discuss and evaluate their work and explain the use of tools, processes and the properties of the materials which they are using. The quality of learning in all years was mostly good. Pupils are well motivated, attentive and generally able to concentrate for extended periods on the work in hand showing creativity in designing and making quality products. They are able to work productively in pairs or small groups.

The department[9], as represented at the focus group session, comprised of:

[9] The group represented a broad outlook on the breadth of subject taught, and appeared to operate as a cohesive group.

The head of department - male, aged 31. He had been in teaching for a total of 9 years, all of which had been in the current school. His ITT had been based on 4-year B.Ed in design and technology.

Design and technology (textiles) teacher - female, aged 34. She had been in teaching for a total of 3 years, all of which had been in the current school. Her ITT had been based on a 2-year PGCE design and technology course, with her initial degree being in clothing design and technology. Prior to teaching she had worked in clothing manufacturing and retailing as well as being a community arts worker.

Design and technology (food) teacher - female, aged 27. She had been in teaching for a total of 3 years, of which 1 had been in the current school. Her ITT had been based on a 4-year B.Ed in design and technology. Prior to teaching she had worked in advertising as a personal assistant.

Design and technology (CDT) teacher - female, aged 29. She had been in teaching for a year (in the current school). Her ITT had been based on a PGCE design and technology course, with her initial degree being in three-dimensional design. Prior to teaching she had worked in design and manufacturing.

Design and technology (CDT) teacher - male, aged 37. He had been in teaching for 3 years, all of which had been in the current school. His ITT had been based on a PGCE design and technology course, with his initial degree being in botany (plus a diploma course in model-making). Prior to teaching he had worked as a special effects technician in the film and television industry.

School 7

This is a GM comprehensive school for boys of 11-19 located on the border of a north London borough and adjacent 'green' area. The number of pupils on roll is approximately 1100. The school is heavily oversubscribed and admits pupils from a wide geographical area. The school's prospectus states clearly the school's purpose which has not changed since it was founded in 1573 for the training of boys in manners and learning. Just over 1% of boys are known to be eligible for free school meals. One boy has a statement of special educational need. The ability of the intake, based on tests on admission, is higher than the national average with few boys scoring very low marks. During 1995 the school admitted pupils based on academic test results with some places reserved for boys with special ability in music.

An OFSTED inspection carried out in 1995 reported, amongst its main findings, that the substantial majority of pupils in the school achieved at least the national expectation in over 90% of the lessons observed. In most of these lessons, many pupils were achieving beyond and, in some cases, well above the national expectation. Achievement overall is higher in Key Stage 4 than in Key Stage 3. The school fulfils its aim to produce pupils who are confident, able and responsible. There is a strong sense of belonging to a community in which high standards of behaviour are expected and achieved. Pupils demonstrate good knowledge and understanding, with high levels of motivation being evident. Pupils are attentive, concentrate on the task in hand and engage with their learning. Well-judged use of investigative work in some lessons adds stimulus and variety to learning. On other occasions, tasks are closely defined and some pupils are reluctant to progress further without direction. It was suggested that more opportunities to take responsibility for their own learning would assist pupils' development as independent learners. Specifically, within design and technology, standards of achievement are generally satisfactory and in many cases good. At Key Stage 3, pupils are highly motivated and respond well to a series of focused practical tasks which develop their competence in designing and making. As a result of this experience, they gain confidence in using a range of materials, processes and equipment. Pupils produce well-researched and well-presented design folders. However, the opportunity to apply skills, knowledge and techniques in a more open-ended situation is limited.

The department[10], as represented at the focus group session, comprised of:

The head of department (head of faculty) - male, aged 40. He had been in teaching for a total of 13 years, of which 8 had been in the current school. His ITT had been based on a PGCE design and technology course, with his initial degree being in architecture. Prior to teaching he had worked as an architect.

Design and technology teacher - male, aged 38. He had been in teaching for a total of 17 years, all of which had been in the current school. His ITT had been based on a Cert. Ed in craft design and technology.

Design and technology teacher - male, aged 44. He had been in teaching for 4 years, all of which had been in the current school. His ITT had been based on a 4-year B.Ed design and technology course. Prior to teaching he had worked as a maintenance engineer and a precast concrete estimator.

Design and technology student teacher ('beginning teacher') - male, aged 49. He was currently completing his 4-year B.Ed design and technology ITT course. Prior to teaching he had worked as a carpenter and joiner as well as instructor in a private school.

School 8

This is a mixed comprehensive school for boys and girls of 11-19 in a north London 'inner-city' LEA. It has approximately 800 pupils on roll, with girls constituting approximately 40%. Pupils come from a wide range of socio-economic and ethnic backgrounds. In addition to English, over 40 languages are spoken. Of the 70% of pupils who use English as an additional language, only 15% are said to be fully fluent in English. Pupils' reading ability on entry to the school is significantly below their chronological age. Just over 1% of pupils are registered with statements of special educational need, an average figure for a London school. The proportion of pupils eligible for free school meals is over 60%, which is recognised as being very high.

An OFSTED inspection carried out in 1996 reported, amongst its main findings, that the high numbers joining and leaving the school each year affects levels of achievement. Two thirds of the pupils are bilingual with 15% at the early stages of acquiring fluency in English. About 40% of pupils have joined the school in year 7, in recent years, with

[10] Very much represented as a 'CDT' department, with no inclusion of food or textiles.

significant reading problems, operating about two years below their chronological age. It was reported that the school has a number of serious weaknesses including serious underachievement in years 7-9, poor results in national tests at 14 plus, GCSE results in the 5 plus A*-G range in the bottom 10% of the country and wide variability in teaching and learning between and within most departments. However, it was acknowledged that the school was making progress with its literacy initiatives. Specifically, within design and technology, achievement was sound to good in textiles but unsatisfactory in all other areas. Learning was best where pupils are engaged in active learning which was not wholly dependent on their skills of literacy. In those lessons, pupils had high expectations of themselves and were sometimes quite rigorously self-critical. In lessons where the quality of learning was poor, significant amounts of time were lost, and pupils' work was superficial and often incomplete. The quality of teaching was satisfactory or better in less than half the lessons seen at Key Stage 3. Pupils' progress through Key Stage 3 is slow and there is little continuity between units of work.

The department[11], as represented at the focus group session, comprised of:

The head of department (textiles) - female, aged 33. She had been in teaching for a total of 10 years, all of which had been in the current school. Her ITT had been based on a PGCE design and technology course, with her initial degree being in creative arts (textiles and English).

Design and technology (deputy head of department) (CDT) - female, aged 31. She had been in teaching for a total of 7 years, of which 5 had been in the current school. Her ITT had been based on a PGCE design and technology course, with her initial degree being in civil engineering. Prior to teaching she had worked as a care assistant and playgroup leader.

Design and technology teacher (food) - female, aged 29. She had been in teaching for a total of 7 years, all of which had been in the current school. Her ITT had been based on a PGCE design and technology course, with her initial degree being in home economics.

Design and technology teacher (CDT) - female, aged 30. She had been in teaching for a total of 2 years, both of which had been in the current school. Her ITT had been based on a PGCE design and technology course, with her initial degree being in silversmithing, jewellery and applied arts. Prior to teaching she had worked as a self-employed designer/jeweller.

Design and technology teacher (CDT) - female, aged 29. She was completing her first year of teaching. Her ITT had been based on a PGCE design and technology course, with her initial degree being in three-dimensional design. Prior to teaching she had worked as a designer for architects as well as in advertising.

School 9

This is a comprehensive school for boys of 11-19 in a prosperous area, north of London. The number of pupils is approximately 760. The school is situated in a county town but

[11] The group represented the various strands of design and technology, reflected in the fact that all aspects were taught in adjacent rooms.

draws pupils from quite a wide area. The most recent intake of pupils reflected a spread of ability similar to that for the county as a whole. There is a lower level of social deprivation amongst the pupils' families than in the local authority area or the county generally. Unemployment, although significant, is at a much lower level than elsewhere in the country as a whole. The school has substantially increased its popularity with parents in terms of first choice. There are approximately 10 pupils who are identified as having special educational needs. Approximately 4% of pupils are eligible for free school meals.

An OFSTED inspection carried out in 1995 reported, amongst its main findings, that it is a rapidly improving school where the standards of pupils' work are rising. Most pupils are achieving in line with their capabilities. Standards of achievement match or exceed the national expectation in all years. The proportion of pupils with grades A*-C in at least five subjects at GCSE was higher than the national and county averages. Pupils make good progress in the development of skills and the acquisition of knowledge and understanding. They acquire good learning skills and habits. The vast majority of pupils have good attitudes to learning and are keen to succeed. Specifically, within design and technology, in general, pupils demonstrate understanding and skills in line with national expectations. The standards of achievement are equal to or above the national average for the substantial majority of pupils. In relation to pupils' capabilities, standards also match or are above national norms in the majority of lessons. At Key Stage 3, pupils make good progress in learning basic skills and in using machine tools. Most pupils worked with enthusiasm on constructional projects. However, the component of the National Curriculum Programmes of Study - 'Systems and Control' - is not being delivered fully. It was also indicated that, schemes of work need to relate the National Curriculum Programmes of Study and Attainment Levels.

The department[12], as represented at the focus group session, comprised of:

The head of department (CDT) - male, aged 49. He had been in teaching for a total of 28 years, of which 10 had been in the current school. His ITT had been based on a Cert. Ed in design and technology.

Design and technology teacher (CDT) - male, aged 50. He had been in teaching for a total of 28 years, of which 4 had been in the current school. His ITT had been based on a Cert. Ed in design and technology. He was actually a redeployed head of department.

Design and technology teacher (CDT) - male, aged 30. He had been in teaching for a total of 6 years, of which 5 had been in the current school. His ITT had been based on a PGCE design and technology course, with his initial degree being in three-dimensional design. Prior to teaching he had worked mainly as a product designer.

Design and technology teacher (CDT) - male, aged 29. He was completing his initial year of teaching. His ITT had been based on a PGCE design and technology course, with his initial degree being in industrial design. Prior to teaching he had worked as an industrial designer.

[12] The department, as represented, was one with a 'CDT' perspective. No one involved in food or textiles was present.

School 10

This is a comprehensive school for girls of 11-19 situated on the outskirts of a very prosperous scenic city. The number of pupils on roll is approximately 1,000. The area from which most pupils are drawn has more advantaged people than the county or national averages. However, pupils have more recently come from a wider and more varied area and a significant number of families have been affected by recession. The proportion of pupils entitled to free school meals is below the national average at approximately 2-3%. The school's intake covers the whole ability range, but with a bias towards the more able. Statements of special educational needs have been made for 2 pupils. About 5% of the pupils are of ethnic minority origin, a proportion lower than that for the city or county as a whole.

An OFSTED inspection carried out in 1993 reported, amongst its main findings, that the school has high standards overall, with examination results which are consistently better than the county and national averages. The school provides a good quality of education, the curriculum is broad, and pupils have good access to all aspects. Pupils are well motivated and learn well by a variety of methods. Although it was indicated, at this time, that the school should address concerns over the progression from the standards achieved in primary schools, and review the levels of work in Key Stage 3, it was also acknowledged that the school is achieving high standards for a broad range of pupils. Specifically, within design and technology, standards of achievement vary widely in different aspects of the work. At Key Stage 3 standards overall are mostly satisfactory or better. Designing skills are good; often very good and sometimes outstanding. Pupils are proficient in investigating, evaluating and appreciating the place of design and technology in society. In CDT the standards of making at both key stages are mostly satisfactory but sometimes unsatisfactory or poor. In home economics the standards of both designing and making in both key stages range from satisfactory to very good. Pupils apply themselves well in all aspects of design and technology at both key stages. There are high levels of individual application, group learning and co-operation. Comments were made regarding sub-standard resources and facilities.

The department[13], as represented at the focus group session, comprised of:

The head of department (head of faculty) (CDT) - female, aged 40. She had been in teaching for a total of 18 years, of which 13 had been in the current school. Her ITT had been based on a PGCE course in physics, with her initial degree being in physics.

Design and technology teacher (CDT) - male, aged 45. He had been in teaching for a total 15 years, of which 8 had been in the current school. His ITT had been based on a PGCE course in science, with his initial degree being in biology. During a break from teaching he worked a self-employed watchmaker.

Design and technology teacher (textiles and food) - female, aged 41. She had been in teaching for a total of 21 years, of which 5 had been in the current school. Her ITT had been based on a Cert. Ed in design and technology (domestic science).

[13] The group was based on the full breadth of the subject of design and technology.

Design and technology teacher (textiles and food) - female, aged 41. She had been in teaching for a total of 19 years, of which 6 had been in the current school. Her ITT had been based on Cert. Ed in design and technology (home economics) with a further year completed which 'converted' the qualification into a B.Ed.

Design and technology teacher (textiles) - female, aged 37. She had been in teaching for a total of 15 years, of which 5 had been in the current school. Her ITT had been based on Cert. Ed course in art. She subsequently completed a conversion course for design and technology.

Information technology teacher - female, aged 44. She had been in teaching for a total of 9 years, all of which had been in the current school. Her ITT had been based on a Cert. Ed in physics and electronics. Prior to teaching she had worked as an engineering apprentice, production controller, as well as physics/computer technician.

School 11

This is a comprehensive school for boys and girls of 11-19 situated at the edge of an urban area of outside of London. The number of pupils on roll is approximately 900. The school has a variety of housing close by consisting mainly of flats or small houses on private or council estates. The local area is broadly average in its social composition compared with national figures, but it has more disadvantaged people than the average for the county. The school attracts pupils from a wide area. Approximately 30% of the pupils at intake have been identified as having special educational needs and the school has pupils of all abilities, but the mean ability is depressed when compared with local and national norms. The LEA has made statements of special educational needs for approximately 15 pupils and a substantial number of pupils receive some additional teaching support. There are very few pupils from ethnic minority backgrounds and few languages other than English spoken as a 'mother tongue'. Approximately 13% of its pupils are eligible for free school meals.

An OFSTED inspection carried out in 1994 reported, amongst its main findings, that it is a well-ordered school based on clearly defined values and attitudes. It succeeds in creating a happy and secure community which supports learning, with an effective pastoral care system. The school provides a broad and balanced education for its pupils. The subjects of the National Curriculum are in place but under-developed in some areas and cross-curricular aspects, themes and dimensions are not clearly identified in practice. The standard of achievement of pupils in most lessons is satisfactory or better. The school does well for many of its pupils, particularly the less able and those with special educational needs. The school focuses on ensuring that pupils have a fundamental knowledge, but understanding and skills are not sufficiently developed in order to be transferable. Teaching is generally sound but narrow in focus and this inhibits the development of pupils' skills and understanding. Some pupils are not sufficiently challenged and too few opportunities exist for pupils to take initiatives in class. Specifically, within design and technology, at Key Stage 3 standards of achievement are generally satisfactory. In the most successful lessons pupils work with enthusiasm and lessons are well planned with an appropriate pace. All pupils learn through a variety of experiences both practical and theoretical. However, the development of individual creativity and the level of skill acquisition are limited. It was noted that at Key Stage 3 pupils follow a carousel arrangement, and that although they experience a broad range of specialist subjects, they are not at the depth necessary to build adequately on their prior experience. This was considered to be a major factor in limiting the development of design skills and needed urgent review.

The department[14], as represented at the focus group session, comprised of:

The head of department (head of faculty) (CDT) - male, aged 44. He had been in teaching for a total of 22 years, all of which had been in the current school. His ITT had been based on a Cert. Ed in design and technology. This was subsequently 'converted' into a B.Ed through a 3-year part-time course.

Design and technology teacher (CDT) - male, aged 42. He had been in teaching for a total of 14 years, of which 7 had been in the current school. His ITT had been based on a B.Ed course in history and design and technology. Prior to teaching he had worked in the 'city' (financial and commercial centre of London), as a journalist, as well as a range of other jobs.

Design and technology teacher - female, aged 44. She had been in teaching for a total of 22 years, of which 20 had been in the current school. Her ITT had been based on a Cert. Ed in design and technology.

Design and technology teacher - female, aged 46. She had been in teaching for a total of 24 years, all of which had been in the current school. Her ITT had been based on a Cert. Ed (extended and converted immediately to a B.Ed through a further year of study) in history. She had retrained 'on the job' with the help of the head of department.

Design and technology teacher (CDT) - female, aged 41. She had been in teaching for a total of 5 years, all of which had been in the current school. Her ITT had been based on a PGCE design and technology course, with her initial degree being in architecture. Prior to teaching she had worked in architecture and as a freelance designer.

Design and technology teacher (food and textiles) - female, aged 40. She had been in teaching for a total of 3 years, of which 2 had been in the current school. Her ITT had been based on a B.Ed course in design and technology (food and textiles). Prior to teaching she had worked as a radiographer in the National Health Service.

Design and technology teacher (CDT) - male, aged 32. He was currently completing his initial year of teaching. His ITT had been based on a PGCE design and technology course, with his initial degree being in graphic design. Prior to teaching he had worked as an advertising and graphic designer and illustrator.

Design and technology student teacher ('beginning teacher') (CDT) - male, aged 27. He was in the final year of a B.Ed design and technology course. He had previously worked as a motorcycle courier as well as run a transport business.

School 12

[14] The group was based on a strong faculty identity which included the broad range of specialist areas in design and technology.

An electronic version of the OFSTED report was unavailable on the web site. OFSTED did not have a version on paper and the local libraries also did not have a copy. Despite numerous requests made to the department and school I was unable to get hold of a copy of the report. However, I have been able to present the equivalent sort of detail from alternative sources.

This is an average sized comprehensive school for boys of 11-19 with a joint mixed sixth form. The number of pupils on roll is approximately 750. The school is voluntary aided in partnership with the local education authority. The school recruits from a large number of primary schools and admits a full range of ability including those well above and below average in terms of reading test scores. Approximately twice the national average of all pupils (30%) is entitled to free school meals. Almost one third of 11-16 pupils have special educational needs (which is above the national average). The most common needs concern learning, emotional and behavioural problems. There is considerable diversity in the ethnic background of pupils in the school. Pupils come from some 70 countries of origin and have over 40 home languages.

At the time of the OFSTED report it was noted that the GCSE pass rate for 5 or more passes at grades A-C was at the national average for boys and above that of the local authority. Pupils were gaining better A-level results than their GCSE results would have predicted. Attainment in lessons observed was satisfactory or better in 68% including 15% that was good or very good. Pupils at either end of the ability range were underachieving. Standards in English and mathematics were satisfactory or good, science was satisfactory in the sixth form but with weaknesses at key stages 3 and 4 and there were weaknesses in history and music at key stage 3. Other subjects were generally good in the sixth form and satisfactory at key stages 3 and 4. Specifically, within design and technology standards of achievement were satisfactory at key stages 3 and 4 although GCSE results were disappointing. Some pupils' behaviour at key stage 3 was unsatisfactory. Teaching was effective but the full requirements of the national curriculum were not being met. Accommodation is dull and cramped.

The department[15], as represented at the focus group session, comprised of:

The head of department (CDT) - male, aged 33. He had been in teaching for a total of 11 years, of which 1 had been in the current school. His ITT had been based on a B.Ed course in design and technology.

Design and technology teacher (deputy head of department) (CDT) - male, aged 41. He had been in teaching for a total of 13 years, of which 6 had been in the current school. His ITT had been based on a B.Ed course in design and technology. He had previously worked as a motor vehicle technician while completing an apprenticeship.

Design and technology teacher (CDT) - male, aged 28. He had been in teaching for a total of 4 years, all of which had been in the current school. His ITT had been based on a B.Ed (shortened 2 year route) in design and technology.

[15] The group represented a strong identity as a 'CDT' department.

Design and technology teacher (CDT) - male, aged 34. He had been in teaching for a total of 3 years, all of which had been in the current school. His ITT had been based on a 2 year PGCE course in design and technology, with his initial degree being in geography. Prior to teaching he had worked as a community artist and screen printer, photographer, youth worker, landscape gardener and carpenter.

Design and technology student teacher ('beginning teacher') (CDT) - male, aged 42. He was completing a PGCE in design and technology at the school. His initial degree was in fine art. He had previously been the design and technology technician at this school. Prior to being a technician he had worked as a cabinet-maker and museum technician.

Appendix H

Focus Group Interviewee Details Pro Forma for Teachers

FOCUS GROUP INTERVIEWEE DETAILS – (TEACHERS)

Name: **School:**

Age:	**Sex: (please tick)**	**M**	**F**

Number of years in teaching:

Number of years as a teacher of design and technology/technology or precursor to this subject (if different from above):

Number of years in your current school:

Any other subjects you are currently involved in teaching in your current school:

Any other subjects you have previously been involved in teaching in your current school:

Any other subjects you have been involved in teaching in your previous school/s:

Briefly describe any current position/s of responsibility or role/s within the design and technology/technology department/area: **(How long have you held this position or had this role?)**

Briefly describe any substantial INSET courses involving design and technology / technology:

Briefly describe any substantial INSET courses involving problem solving:

Briefly describe any one-day INSET programmes associated with problem solving in design and technology/technology:

Briefly describe any one-day INSET programmes associated with problem solving:

Type of initial teacher training: (please tick)

PGCE	2 Yr B.Ed	4 Yr B.Ed	Other: (Describe)

If you did a PGCE, what was your first degree and when did you graduate?

Where did you complete your initial training course?

When did you initially qualify as a teacher?

Was your initial teacher training in another major subject?
If so, what subject was it?

Did you attend a conversion course?
If so, where and when?

Have you attended any further courses leading to higher/further qualifications?
If so, what, where and when?

Previous experience:

Briefly describe any previous experience prior to teaching if you did not go straight into teaching:
(Please give approximate dates)

Intermittent experience:

Briefly describe any other experience in any breaks in your teaching career:
(Please give approximate dates)

Appendix I

Prompt Sheet - 'Lead-in' to the Focus Group Interviews

Prompt Sheet - Lead-in to the Focus Group Interviews

1. The Welcome
2. The Overview & Topic
3. The Ground Rules
4. The First Question

I am involved in research into science and technology education (as part of the STERP group at the university).

I am inviting people to share their ideas and opinions about problem solving in D&T at key stage 3.

(More detail at the end, if necessary)

Details to be completed on the pro formas for me – simply for background information, etc. – not to go to anyone else.

My role – as a listener – not making any judgements.

"There are no right or wrong answers, but rather differing points of view. Please share your point of view even if it differs from what others have said. I am just as interested in negative comments as positive comments, and at times negative comments are the most helpful."

The first question is designed to engage all participants one at a time… we will go round in turn initially in response to the first question, and then you should 'chip in' whenever.

Seek comments from the participants at the conclusion of the first group discussion.

'General Probes'

- Would you explain further.
- Would you give me an example of what you mean.
- Would you say more.
- Is there anything else.
- Please describe what you mean.
- I don't understand.

Appendix J

Representative Sample Focus Group Interview Transcript - Teachers

FOCUS GROUP INTERVIEW TRANSCRIPT
'TEACHERS 5' - 14/7/95

Teacher 1 - *D* (H.O.D.)
Teacher 2 - *A*
Teacher 3 - *G*
Teacher 4 - *M*
Teacher 5 - *S*

Question One **- What do you think about <u>problem solving</u> in design and technology at key stage 3 in terms of its <u>educational merit and value</u>?**

D I think as a philosophy of the way people... erm... go about their life, that problem solving is a very strong concept to learn... and in the past in education I don't think there was much chance for children to problem solve in its true sense... they just had to write answers or *get* the right answer... and we do a much more open way of doing things now which should mean that when they leave school they are more able to transfer skills between different jobs or between different fields of their life.

A Erm... well, I agree with that as a very worthwhile concept educationally... but I *don't* know whether the children see technology in terms of problem solving, you know... I mean, it's quite hard for them.

G I agree with what everybody else has said, but from the point of view – picking up from what '*A*' said, I think often it conflicts with the other skills that they learn in other subjects... and I think they become very dependent on the teacher and can't really see the teacher as the facilitator in a problem solving role... they see them more as: 'well how do I do it?' They're very often reluctant to problem solve for themselves... and I think there can often be a conflict there... especially if other subject areas work in a completely different way.

M Erm... problem solving traditionally was found in higher education rather than secondary, and the reason for that was because the number of skills learnt as a vocabulary went in place of... erm... school education... and the children were often shooting in the dark when they did try solving problems – I mean this is not technology, it's science and geography among other subjects – the main concern, if you are going to embark on problem-solving exercises with the lower school, is to make sure that your vocabulary, skills and knowledge that they need is adequate for them to make that cognitive leap... and if you don't then they are always going to be turning back to the teacher to... you know: 'what do I do next?', because they won't know.

S Erm... well, I believe it's a very important and necessary part of technology... problem solving... and it's one of my strengths that I try and help other children to learn the same principles... and what I have done is give them a focused task which isn't complete and then in order to complete it they have to solve the problem, and it could involve any kind of material but they have to work out how to join whatever they have made to the final item in order to make it complete... and I usually say:

this is your problem, go and think about it and come back to tell me what you've got, and if they do have a hiccup and can't surmount the hurdle, then I could give them another clue as to help them solve the riddle themselves... but I try very much to impress on them that it's their problem.

Question Two **- How do you feel about teaching which involves problem solving in design and technology at key stage 3?**

Probe - What do you think is most *problematic* about it?

D In some ways the most problematic thing is that if it's a true problem you don't know what the solution is yourself – so... it's the ownership much more with the pupils – erm... there's been swings in education backwards and forwards for years... erm... and I think there is a sort of middle ground where problem solving can be very effective, where the pupils are in control, and their own solution is theirs, but the teacher has sort of guided them along the way... erm... and a lot of teachers can feel very threatened by not being in control. As a technology teacher I think we're in a lucky position, we're used to it but I know in other fields of the school it can be a real problem.

S I actually don't like it when the kids put me in control of their project because then it ceases to be their design... it becomes my design which I wouldn't necessarily have started in the way they did... so I will try and thread it back on them in a manner which doesn't sort of frighten them to death.

G I was going to say, I think it comes down to the personality of the pupil and sometimes children can be very confident and they'll adapt to whatever situation they're put into, and they often enjoy working in groups on problem solving rather than there being the isolation of working on their own, and trying to get them to communicate with each other. But then the weaker ability ones, I think sometimes they can be very very confused about the lack of structure... that's why I think it's important at this stage in year seven, it progresses through and they build up their confidence in problem solving and I don't think they should ever be set a task that they could perhaps fail at... it's so important that the outcome to the problem is that it is solved... whether it be that it fell apart, but they learnt something from it, and I think that's often the view – the feedback at the end often gets lost at the end of the lesson or whatever... and I think that's important to be built in... that the children see at the end of the day that they've solved the problem even if the solution is not the right solution but there is that... kind of, like, progression through.

D ... it can differentiate in itself as well... because they're not...

G Yeah.

D ... the more able ones can go on to more... erm... a better solution as it were... the others can still manage to succeed.

G Yeah... I don't think you can just say: oh, just solve this problem... you know... it needs to be structured from year 7, they need to develop.

A Yeah... they need to have the skills and knowledge in order to solve that problem at that age or they get very frustrated.

M I've seen a lot of – while I was training I saw a lot of – naming no names, but technology lessons where the kids were, to a large extent, left on their own to build a frame of a buggy or whatever and there was about a ninety percent failure rate on the project... it had a very negative effect on their attitude to the subject and to their learning in general because they felt that they come out with nothing after spending six weeks hacking away with some saws and glue... and erm... I would rather pay the price of, if you like, structuring the project much more carefully so that that didn't happen. I don't think it's a good idea for children to avoid failure but I think that you've really got to make sure that they do have a fair chance of transferring skills from somewhere else, that they have formally learnt, into the new situation... and the age at which they're able to do that would vary from child to child... they'll reach that stage of competence at different ages... it doesn't all happen in year 9... or something like that... it can happen much lower down in the school with particular children.

Probe - Again... that's gone onto the next question which was to do with how <u>pupils</u> *feel* about it...

(Question Three - How do you think the <u>pupils</u> feel about being involved in problem solving in design and technology at key stage 3?)

Probe - ... so, anything else on...

S ... what I've found is that when I've had an insecure kid who may have – which has happened this week – has gone on holiday and so wasn't able to finish the project and her evaluation – her criticism, maybe, of my project was that she didn't know what she was supposed to be doing... but then *none* of them knew what they were supposed to be doing... and they weren't supposed to know what they were doing anyway, they were supposed to solve the problem... and create something which was a specific task told to them at the beginning... so that they can panic... and once they panic than they lose touch with their own project.

G I think often here as well – I've noticed it more here than the previous school I was at – some children will opt out and then they see problem solving as a way of opting out... and they will choose to opt out of problem solving or they will choose not to do it to their capability... because they can see they have a choice, the responsibility is more their's to learn and their responsibility is more their's to produce or to activate their own way... and some of them will opt out of that, and I've found that more here where the emphasis is very much on: 'well, you're the teacher so you should tell me'... and I think that you've got to be careful with that – I think anyway because some children will just become, not even demotivated, but just will not achieve their potential, because they choose not to...

D ... we've got a problem in this particular school and perhaps in the other schools in this area – that's not the same as in other parts of the country – that because of the... erm... sort of, the academic background of the school, the pupils have been spoon fed an awful lot and the teachers are used to spoon feeding then... and so, when they come into an area that isn't, like, the same as one of their other subjects, they can then switch off and give up and say, like: you should be telling me, you're the teacher... and that can be slightly negative. On the other hand, I think children do enjoy – especially on the short, sharp projects, rather than the six or eight week or ten week project, that's a problem-solving thing... the one-off build a paper tower, build a paper bridge, or whatever it might be... they do sort of tend to enjoy that on the whole because everyone can succeed... and they're working in groups or...

M And the materials are familiar... very familiar.

D Yeah... yeah... the actual concept they're trying to get through might be something they've never come across before... but they know that they can cut it and they can stick and they can – they've got a fixed time of an hour or whatever it might be to do it in.

G I don't know whether it comes through from primary schools where they're very much involved in that in primary schools – in year 7 you find that they're very enthusiastic about it and they like that... then by year 9 their interest seems to have wavered by that stage and they're not that interested and can't be bothered... and I don't know where that enthusiasm goes at year 9 because they're so enthusiastic in year 7 and 8.

D Yeah, they eat up the materials.

G Yeah... and they want to know and they're interested... but when they're year 9 it's hard work...

S ... but by year 9 they're actually critical of the projects... 'why are we doing it?'...

G ... other subjects become more...

M Can I say quickly that the same thing happens in science...

D It's... yeah... it's partly attitude of the parents... /?/... in this school they want their children to do well because they made a specific choice to send them here for whatever reason... and to come out at the end with a handful of good certificates... and all that pressure – although they might not be saying it, that technology is a 'Mickey Mouse' subject or that problem solving doesn't work, but whatever, you might say that it's a sort of black and white area – that it's a very grey area, and the parents probably influence pupils away from subjects that aren't going to give them a... I don't know... English or maths.

M I think a lot of parents are quite unclear as to what the subject is and I do spend a large proportion of parents' evenings actually talking to them in terms of what *they* did in school and what it is now... and the other thing... erm... that... erm... they are – when I started to teach science, parents' evenings are quite different... with the queue of parents waiting to see me... whereas with technology I just got the odd one – and I was talking throughout the evening with a queue... and you can see very quickly... I mean, there are certain subjects where the parents know that the child is *never* going to be taking at GCSE... erm... they are going to just chop because it actually doesn't make sense to take that many subjects at GCSE – it's a personal opinion... and I know that the private sector does not operate along these guidelines at all... where many people only take six GCSEs...

G Bringing it back to a project level... I think it's sometimes the length of project... /?/... and they can get bored... they see problem solving in one lesson is very effective... problem solving over four lessons... they get fed up with the problem...

D Yeah... we've just done 'Insight into Industry' with year 9 and they do six projects over two days... erm... each of the projects are an hour-and-a-quarter long... all different problem solving – I mean, completely different set up in each room and they thoroughly enjoy it... erm... partly they're off timetable and in their own clothes, but they're also doing short, sharp problems. When they come to technology – every lesson, you can say, there has been a problem in there that they've had to solve – they see the greater picture of – this is fourteen weeks stuck in this room with this teacher who I don't like particularly, or do like particularly, whatever it might be, and I don't really know what I'm supposed to do... and it all becomes a bit 'woolly'.

G Yeah, they don't actually recognise when they've solved the problem I think – I mean, even when you turn on the cooker you solve the problem of turning on the cooker, but they won't recognise that... and they still come and say: how do I turn the cooker on?

D 'Where's the paper?'

A They actually enjoy the three weeks skill session... /?/...

M Remember that photo you had (aimed at the interviewer) of you doing the rocket project... at 'G.O.' wasn't it?...

Probe - Yeah.

M ... and all the boys are standing 'round the rocket and there's three girls underneath the edge of the building... well, here there's no boys to stand around the rocket.

Probe - Right... yeah... so it makes a big difference – okay.... erm... the next one is... again, this had already cropped up, but...

Question Four **- What do you think about the <u>characteristics</u> of problem solving?**

Probe - ... Do you think there are different *types* of problem solving?

G I think that problem solving is underestimated... /?/... I think it's quite a complex thing to do effectively... anybody can problem solve but actually to teach it effectively I think is quite difficult... and I don't think it's ever been come to terms with, neither at teaching practice level or at classroom level, I don't think it's ever been taught to me effectively.

D That's where some of the other teachers find it threatening in other subjects, where they've suddenly been landed with this idea that they should do projects... that they've never had to do before... and they've had no training in how to run a project or how to manage a project – erm... within that project they might have to do some problem solving and that's even worse because they've never done any training on that either... and they think.../?/... technology teachers have been trying to do it for years... they may not have been trained in it but they've been trying to do it... and so it's not quite such a threat... but even that... even saying that, it is still a threat to some people.

G I don't think they like the unpredictability of the outcome and they don't like it with children... /?/... responsibility, and I think it's been very very poorly acknowledged, and I don't think it's ever been given a fair chance.

D It's almost impossible to assess properly... in some ways, because if everyone is aiming to succeed then it's very difficult to say: oh, that's an '8', because everyone has got an '8', but the world outside doesn't want everyone to have an '8'.

G It doesn't... it runs against the grain educationally... traditional education anyway... which more people seem to be moving back to – whether more people *here* do I don't know, I can't really say... but, I feel sometimes we're running against...

M I think – I wouldn't agree with that, but I would...

G But you teach science you see...

M No, but what I'm thinking is that it's not so much running against the grain... I think that as far as education is concerned there are several aspects of problem solving which are not in the educational mainstream and some which are, for instance, testing somebody's ability to mentally model, are you treating their ability to transfer skills, or are you testing lateral thinking, which actually is very little to do with what they already know... and you could have a number of other factors... I mean that's a very simple example... you can have a number of other factors which will bear on their success... and, erm... some of them can be taught, others can't... they're actually something which is innate if you like, in that person, and it doesn't bear any correspondence to their teaching group or their ability in another subject... I mean you can have somebody in later life who is a manually skilled person who's never got any formal academic qualifications, but they can be far far better as problem solvers as adults, than somebody who has a doctorate.

Probe - Do you think there is some form of *hierarchy*... in something like different types of problem solving?

M No, I think that – you know, government ministers say that they can't discuss any case specifically... /?/... each problem is a little world in itself... and the factors bearing on it... particularly to that situation.

S I think the kids have to... erm... decide for themselves what exactly that individual problem is, or about... what kind of problem is it... is it like a thinking problem or a skills-based problem or what and that takes an awful lot of time to learn on their part... and once they've learnt what kind of problem it is... it's then they can... erm... find the answer to it... it's *then* they can... erm... find the answer to it... that they can try to solve it.

G ... /?/...a lot of them don't go through that process – and you might see it differently – I don't actually think they go through that process... they fumble their way through.

M ... so do individual designers in real life... they don't go through it...

G ... and I think we fail them in that respect in that we don't clearly...

S But often what I do is I give them a problem... how are you going this little quality product and then they'll say: oh, I could do this... but if you're going to do this how are you going to go about it and then it all falls apart... and then they have to go away and think about how to solve the second part in order to achieve the first part.

D You know when you mention about hierarchy... *'G'* said about turning the cooker on is a problem in itself... there is a hierarchy in that there are big problems and there are small problems... or that you might consider to be small problems... but to each individual – whatever that problem is, it can be a terrible insurmountable mismatch of knowledge... erm... turning the cooker on for some girls is going to be terrible – erm... I'm actually CDT based, or construction-material based, and to get some of them to turn a drill on is a terrible problem for them... never mind actually being able to drill the hole. So... you know, with some of them the problem would be making a ball bearing game and there isn't much of a problem along the way, and the problem is actually how it is going to look at the end, but for some others it will be: how do I turn that drill on?, I'm not turning that drill on...

G ... I think coming back to what *'M'* was saying... in a way... I think it's where you differentiate problem solving as an activity and problem solving as just a general... you know, you've got to do this to achieve what you want to do... and *'S'*, I think, does problem-solving activities. I think sometimes the problem doesn't really represent itself as a problem... it's just kind of like: 'well what am I going to do, how am I going to do it, what do you do next?'...

A ... they see it as just making things... they don't see it in terms of problem solving at all...

G And that comes through in their evaluations, doesn't it... they're so poor... because they haven't really been thinking about the process...

D ... 'I should have done it in blue'...

G ... 'it was good'.

Probe - Erm... it's kind of the OFSTED question now... and again it cropped up earlier, but...

Question Five - **How do you allow for <u>progression</u> and <u>differentiation</u> when teaching design and technology involving <u>problem solving</u>?**

D Well, there's differentiation by outcome... in general terms in technology anyway – but the better girls will not necessarily produce a better outcome in the same amount of time... but they will tend to spend more time on it... so it's more quality time – so there's differentiation by outcome anyway. There's differentiation along the way because of where you... where the teacher sticks their oar in... erm... and how much help and guidance pupils need... if it's an open-ended project then the pupils are very much in control for a majority of time... but some of the higher ability girls will be able to cope with that and run with the project... some of the lower ability girls will need a lot of support... and that's where the balance of the teaching comes in... where you spend your time.

M I find... erm... so long as you've got the structure of the project very clearly mapped out... erm... you can, if you like, split your time – some of the pupils are able to work on one or two simple written instructions or drawings and others will need a lot of... as you say... guidance and support... and erm... the ones who've achieved the sort of basics of the project who've built the basic thing... used the materials... and then predicted what was going to happen – you can then move them into a far more sort of a constrained design framework... which the others *perhaps* reach by the end of the project... perhaps not. But it's very important to have more or less the sort of end points of each part of the project very clear before you start so that you've got sort of – you can work something out for three weeks in advance and say: well, look this is what your... the stage you're at... you know... here you are... see what you can make of this... and erm... they tend to move at different speeds as a result of this.

S But I've done that with year seven with the bird box... I made the bird box at the same time as they did with the same parts... and because of my skill I could make it a lot quicker, and I had more time to teach them and show them where they were going wrong... but when it came to fitting other parts on which was the next stage, or maybe two stages later, where they had to cut out the part, now and then I could say: go and look at mine, compare your piece of wood with my piece of wood in the same part and how are you going to achieve that end result?... and I would stand there and wait for them to fumble about or to come up with the right answer, and if they did well that's fine, a pat on the back clever clogs, and if they didn't then I'd walk them through it step-by-step, but they would do it... I would, however, give them the answer.

M I think the other thing... when people hear the word differentiation it goes 'clink': lower ability, but you've got to think of the top end as well... and you know... if you can have work from previous years to display, you can actually push the top level up each progressive year and get better results, because they've got something to compare, as a benchmark... like there's no point in training someone to run one hundred metres without a stop watch – that kind of – you have to have a motivating little mark that they can compare themselves to.

D Within the school there are various systems for assessment and recording and whatever... so, we've got the school report system has a level of one to five... /?/... within a teaching group... I wouldn't support whether it works at all but it's a system we have to do and so you assess within the school system the best pupil and worst pupil on level of one to five... so that's part of the assessment procedure that we have to go through in technology for projects as well... if we don't do it at the end of every project we do it twice a year... but obviously that is built into our assessment system.

G I think it's very difficult to assess though objectively, I don't think you can assess it objectively...

S But I think that's why I tend to mark the projects... not just ten out of ten, but I do a project mark on the end result, or however far they get towards it, and an effort mark... so they can actually be low on their project but they can put in a great deal of effort so they get the benefit of the mark.

D Yeah, that's the one good thing about the report system, is that it does have an effort grade on it... erm... I suppose the worst grade is an 'E1'... where they've done nothing to work and got a top mark... no effort and got top mark.

Probe - Erm... next question...

Question Six **- Do you feel you actually <u>teach</u> problem solving?**

S I think I teach problem identification... and then I help them to solve once they've identified it... or recognised that they've identified it.

Probe - Right.

D We do teach a procedure of the design procedure which can be used to solve design problems... erm... I think we all do that somewhere along the line with every group... so that gives them a strategy to succeed but personally I don't think I teach anyone to problem solve because it's a sort of... erm... de Bono type thing... a sort of lateral thinking thing that's going on inside and I think, it's my argument about arts... that it must be almost impossible to actually teach art... because it's something that you learn – necessarily... it's – there's so many factors involved with it... that tying in to the sort of maelstrom about problem-solving, is we can only offer strategies.

S Yes, well the last thing we want to do is to teach someone how *you* problem solve because... /?/...

D And also, they wouldn't have our knowledge to be able to solve the problem, so we could make short cuts that they could never do anyway. The amount of problems that we have to solve when pupils come up to us is an incredible amount compared to what they're solving... but we've got this background knowledge, that we can pick out a material or a tool or a device or whatever it might be... that they wouldn't be able to do until our age, until they've done it for that length.

G I think we integrate problem solving in what we do without making an issue of it, and that's maybe not very helpful for the children, but I think only through experience have I become what I would call a competent problem solver... I suppose with my own home, with jobs that I've come to do, I now have a logical process of the way I think about, but that's come through... only through my maturity and a need.

S But that's also what can be an innate ability.

G Yeah.

S You can't teach someone who hasn't got the basics.

G But I think it should come through more as what we do in technology because that gives it more purpose – there's always this running back about what we do in technology and it's often that... oh, it's that fuzzy area where you make things in – but they don't – we do a lot more of that and problem solving is an integral part of it which is very difficult for children to learn, and that gives the subject something special that I think they don't get so much in others... maybe in maths they do.

D But as *'M'* said, at parents' evening you have to explain to a parent whose daughter is doing it, what their daughter is doing... without having to try and explain to everyone else as well...

G But I think the children's problem solving is to get somebody else to do it... but in technology we don't allow them to do that... you know... they have to think it through themselves and that can be a battle in itself... because their way of solving a problem is to go and find somebody else to do it.

D That *is* a solution...

G It is... and some people live their life like that don't they, but others will have to scratch around... the majority of pupils have to learn to solve problems for themselves... but that only comes through, I think, with independence and maturity as you leave home or a necessity arises. I think we often have to teach them in very... erm... what do you call it... cosmetic circumstances... you know... where they're not really real are they... you know... and I think the children are very very quick to suss that... and that's probably why in year seven they're a lot more enthusiastic... you can con them a little bit more... by year nine they're saying: what is the point of it?

D Yeah... what is this paper bridge all about?

G Yeah... because we did it with year 12 didn't we and in year 12 I had one girl that said – we had to go across a void and it was across the grass and she very rightly said: what is the point of going across the grass?, and wouldn't think it through any further... so I think by that maturity or whatever, they do question: what is it all about?... why am I doing this?

D Yeah... that's where things like 'Insight into Industry' works really well, because it's off timetable and it's different... and they're willing to give it a try... but even with some of the particular characters in year 9... I didn't hear a negative comment until they'd failed in some way... because the other thing that's built into 'Insight into Industry' is that they don't all succeed.

S But some can take failure quite well... they can laugh it off and enjoy it as part of it, the fact that they failed, others see it as a great... /?/... that their street credibility has been dented because they've failed on that particular day.

D I think that's possibly where the school fails in itself in some ways that we don't – one of the problems that people will come across is failure... and we don't teach the pupils to come up against failure enough.

S But we also teach that there is always more than one solution... that you're not all working to... necessarily to a common end... but often you're working to your individual end... which may be completely different to the person sitting next to you and that's okay.

M Linking it into the subjects of art and science... I think it – in the case of teaching art... you're going to do, just like music – people who have an innate ability... they're going to really apply judgement which basically condenses to... as taste to something they see or hear... others will not, but they won't have that set of associations already built in... so what you attempt to do is you can teach technique... you can teach technique... you can teach knowledge and materials... but you can try to instil some framework of taste... if you like... /?/... 'C1' and 'C2' or whatever, but it is like that – and in science you're concerned with... not so much with taste but with teaching technique and knowledge and understanding... and I think in technology we're really dealing with the same things and the problem solving will come, and that younger children will not be so good at it and gradually begin to acquire background but in the memory which will enable them to do things... some will be good lateral thinkers, some won't – but I think that my primary aim, and I assume I'm sort of in step with the department, is to try to build on the background knowledge, build on the experience and try to give them examples of transferring the skills from one material to another, from one problem to another and so on... and erm... that is what I am primarily concentrating on... rather than setting endless problem-solving exercises.

G But you often find that in technology the problem arises as it's got to be solved, instantly...

M Yes.

G ... and in food that's a real problem: 'my sauce has gone lumpy, what do I do?'... well that's instant, or: 'my sauce is too thin, how do I thicken it?'... that is *instant*, and I haven't got the time to go and say to them: go and read that book and it will tell you how to solve the problem, or: go away and think about it... and that I find difficult in food, they have to rely on me in that respect, and that doesn't get any easier as they go up through the school... and you...

M Yeah... to an extent, I mean you don't want the piece of plastic to catch fire.

G Yeah, plastic... /?/... but sometimes it's an instant problem solving...

M Yeah.

G ... and I often think then that it's disregarded as a problem because it's been solved... by me...

M Yeah, that's quite right.

G ... you know, so it's disregarded instantly.

D That's why it's important for them to keep a folder or a diary or tie it into their evaluations, which is something which is constant, more in key stage 4... so that they...

G They still don't identify it... they are so weak at that, and you'll say to them every week, at the end of every lesson, when they have to write their diary up or whatever, and they will never add it... and you say: write about your experiences, your problems or whatever... /?/... the end of the lesson's come and that's it, they won't acknowledge it at all.

D ... they couldn't choose what colour to paint it... that's been my problem...

M There's a big conflict between their – if they are, as *'G'* says, they're encountering problems – often, with a little help, they are able to solve it... /?/... but the focus of their minds at that point is on wrestling with whatever is in front of them and to – it's almost completely impossible, really, unless you sort of lay down the law to get them to go and write down what's happening, because it completely breaks their interest, breaks their train of thought... and then to ask them, at the end of the lesson, to go back and recall – I mean, it might be possible on a one-to-one with hypnotherapy but in reality I... you know... I don't expect to get very much of that kind of evaluative comment.

D There was a comment from someone – we had a year 10 exhibition last week... and there was a comment from someone there, who I was talking to, that said the idea of technology was a wonderful thing and it was nice to see all these things that people had made but what a waste that they had to write about it... and in effect that's the only bit of assessment that the examining board ever see because they don't come and see what they've actually made... they might see a photograph... you know, they see a nice project folder that's nicely presented and looks like... and alright, there's all sorts of wonderful things to do with project folders but at the end of the day they're writing about an experiential thing, that if they're writing about an experiential thing that if they've been internalised they don't need to write about.

M And the DFE actually came out with this thing in 1992 didn't they, that... the bottom line for schools' technology: 'is it effective and does it work?'... in a really simple sentence – in fact, the whole assessment curriculum is nothing to do with that in practical terms... they said one thing and actually in practice it's another. If you listen to the radio... and the comments that current affairs programmes come out with – I mean when the 'Dearing Review' came in they said: oh, teachers have now lost one third of the timetable, what are the children going to do with this one third of the time that's been created? – so, you have that type of perception, and the other one was... that I'll always remember... is: oh, schools' technology is changing because instead of making table lamps they're now going to write about how they would make a table lamp, and I think that, to a large extent, is certainly the perception in the newspapers, magazines, and the radio and television... that... erm... most people see it... see this type of writing and documentation as completely futile...

D Well, we do to a certain extent, so it's hardly surprising.

M But professionally we can't admit to that... certainly not in the present set up... you know, with school inspectors and stuff like that.

G In fairness though, I think we demand a lot from them...

M Yeah.

G ... I think technology demands an awful lot from them and I don't think that if anybody, or even pupils, quite acknowledge what goes into them and I question sometimes, when they reach the end of key stage 3 and they go on to key stage 4, what they have actually learnt and whether or not *they've* actually thought about what they've learnt. In other subjects they have a book or a folder and they can see that progression... here they will often have bits of paper or bits of projects... and fair enough, that they've completed or they've finished, but I still feel they compartmentalise a lesson and they don't actually progress through – the progression is very weak they'll come in to, and I think that's partly from working in multi-media areas or it's time to move on again, now forget everything we did there, and they forget everything at the end of a week and...

M That leads on to a big problem which a lot of schools have is: what do you put in a year 8 technology exam?, you know, what do you examine them on, on paper?

Probe - Yep, okay, two more questions... erm, next one is...

Question Seven **- Do you have <u>access to any information</u> about teaching involving problem solving?**

Probe - that could be from your original training, previous experience, INSET.

A No INSET.

D No... in filling in your questionnaire I put: 'Learning for a Changing World', but that was six years ago or seven years ago... and really (the LEA) haven't been interested in running that sort of course. There's been an awful lot of courses about... erm... teaching electronics with technology or teaching food within technology or whatever it might be as a specific area, but with the funding being cut and cut and cut we're not even getting on those sorts of courses... our budget is minus two pounds at this moment and we only got it in April...

G I went on a course actually, having said that... at the Institute of Education for newly qualified teachers, and their's was based on generic skills, not subject specific skills, and that I found useful in so much as it gave you a lot of ideas of how to teach... the generic skills rather than this subject based skills and one thing and another. It was more a cross-curriculum, but I question whether or not, because we're all separate teachers working in our own way, the children pick up on those skills... I don't think they actually acknowledge ways in which they can research and things like that, and I don't think they acknowledge the design process. I don't think they acknowledge ways in which they can research and things like that, and I don't think they acknowledge problem solving in that, and I don't feel that I really communicate that very well at all, I wouldn't know where to begin with – I think I do it, as I say, integrated into what I do, but I don't do it specifically.

A It's too nebulous a concept actually, you know: 'today we're going to'...

S But even when you get similar problems like in T1 and T5 are two workshops... because the drill is in a different part of the room in T2 to the one in T5, they haven't a clue what it's doing there, what it's for, how to use it, suddenly what they've been taught when they were in the previous workshop is out the window and they...

D ... too far to use a drill...yeah... there hasn't been much INSET support and generally speaking there is very little INSET support from... within (the LEA) at all... /?/... because it's cheaper than going to other counties... but... erm... there is very little – we have – it has been suggested that we bring advisers into the school because it's cheaper than us going out... because the expensive part of the course is getting cover... erm... and we've had *'R'* in a couple of times who's our adviser... erm... but she's been very helpful but there have been so many initiatives and so many bits and pieces to sort out with OFSTED and all the rest of it, that things like what we actually do doesn't come up as an important issue any more.

M I'm conscious of the fact that having entered education from industry I'm dating as it were in that my access to new information is really limited because I'm always marking and assessing and planning projects, and I don't have time to read up on current technical developments and things like this... I'm relying on what I learnt in industry or what I learnt from teacher training, and pretty soon that will become outdated and there is, as far as I can see, very little chance to develop and keep up to date, and I can see... you can see, sort of, teachers who are sixty or whatever and – erm... particularly with problems like the information technology, it really does become a sticking point.

D That's perhaps why – or one of the reasons for that is that the average turnover of staff used to be no more than five years in the profession... so you get an awful lot of dropout very early on... so you don't have that problem of their knowledge being old because you're only in the profession for a few years at a time, but there will be some who will stay in the profession for thirty years.

A But I found that the knowledge I have from industry is far too sophisticated for what technology courses demand in terms of skills and knowledge and scientific developments...

M But there can be suddenly very big changes in industry... car panels used to be stamped out...

G I don't know, I think that technology desperately needs to link somewhere with industry, industry has got a hold of all these new skills that children need to learn and they're passing them on through the employers that they work with, I think our – the children will when they get there, and I think that is a big weakness really... I don't think we actually teach them those kind of skills and they wouldn't transfer them, I think they might think about it at the time when they're presented with the situation if they're – they have a good initiative and they understand: right, take the initiative here and do that – I think there is a lot of them that won't... they'll have to be retrained in industry for those problem solving skills and those kinds of things... where really a lot of it we could have done perhaps better in schools...

D But in a lot of areas there is a lot of industrial support and we have 'Neighbourhood Engineers'... we have 'Young Project Engineers' in the sixth form and all sorts, but we're actually in the middle of a desert of industry... there is 'Glaxo's' up the road and there is loads of one-man industries... so, to get an industrial – although, I agree there are an awful lot of things that industry can do for schools in this particular area and in these particular circumstances, unfortunately, there is very little they *can* do.

G Because they often learn a lot of those skills... problem-solving skills and things like that with work experience.

D And the girls have a wonderful time when they go out on work experience.

Probe - Erm... last question...

Question Eight **- What do you think about the relationship between <u>problem solving</u>, <u>creativity</u> and <u>designing</u> in design and technology?**

Probe - Are they closely linked, one-of-the-same, very distinct, do they get confused?...

G They definitely get confused, I think, in the children's point of view.

D No, I think designing – there's a distinction between those three words – that's probably the reason you've chosen them anyway isn't it – but, designing is a formalised way of doing things... creativity is completely nebulous... problem solving is... /?/... but there is a practical outcome... erm... so, yeah, there is – I would say there is a distinction between the three words... erm... as in what we do, I think *we* fudge the distinction, and we allow the pupils to be creative or they're solving problems in design briefs as it were... so all three of them end up sort of fudged together... the end product is a design brief that has a solution... erm...

S But then, if like I do with year 7, I give them a project where they *all* make the same thing, it's very much a focused task, just learning a skill and it's... /?/... building a bird box, and we end up with twenty bird boxes that look amazingly the same, you've got to allow them to have some creativity and to use it and to develop their own creativity – even the problem of being creative throws all manner of different things they have to surmount – so, if you start slowly with them and give them the skills in which they can move ahead and learn from as they go up through the school... /?/... if you start with this enormous mountain of a problem that they have to cope with, that's when they get frightened, and they don't want to work at all.

D You know, you have to... for them... they have – in my opinion they have to have some sort of ownership of the project, but myself and *'M'* were talking earlier on about if they're doing something that's very much teacher-led... if they have *no* interest in it at all they don't want it at the end of the day... it's something they've done for the teacher – erm... if they get the chance on the bird box to do something that's different, suddenly that bird box is their's... it might look the same as everyone else's in the room apart from the peg's in a different place, or the hole's in a different place, or the lid works differently, but it's their's, and they can run with it and they can use those skills again and again because they can start to internalise it.

S If there is no ownership of the project and they can see that half way through then they'll give up half way through...

(End of side one of tape - tape turned over)

M The sort of ideal project that I have a lot of success with... is one where they went through a fairly constrained exercise in which they picked up skills learnt about the materials and all the other things they need to learn, and then the second stage where they actually build something themselves which is based loosely on what they draw and the help and guidance, and hopefully that forces to transfer skills and fixes them in the mind – erm... I think a lot – last word, if you like – erm... a lot of people don't – the problem about technology, going back to the problem of what will you examine them on at the end of each year because it is largely what you have taught... been teaching them... as *'D'* said is internalised – erm... I think our best defence is to say that what the hand's learnt, the mind doesn't forget.

S I don't know... I am amazed sometimes with their creativity... I'm absolutely amazed with the idea that something they will come up with... but then I think they get frustrated sometimes... especially with technology in that: does it fit the purpose?... and in food in particular they say: well, I can eat it – so that... their creativity and their ability to do things sometimes amazes me, and I think we sometimes stifle that and, in particular towards the end of key stage 4, I think sometimes that key stage 3 going into key stage 4, sometimes that it becomes very restricted and they are not doing a project for the creativity they're designing, and maybe the originality may become boring and they become – they think: let's just get through this, let's get rid of it and let's get out... /?/...

D And it is also that...

S ... and it becomes a secondary subject...

D ... they're turned on and turned off at certain times, aren't they... there are certain projects in which they can be extremely creative... they can do all sorts of wonderful things and it's all very free, and then there are projects where we say: right, you're going to make this, this and this and at the end of the day you will have that sitting there... erm... and we're expecting them to be able to switch on and off at our say so... which is not always going to work, obviously... sometimes it does, sometimes there isn't a problem with some girls, they're happy with whatever you throw at them... and as I've said before, that they get qualifications or assessment success in spite of the teacher... erm... because good girls do well and bad girls do badly.

A But there's an awful lot of confusion on their part isn't there about what it's all about... they get confused between different areas, having to do a GCSE...

S But you could say that about any of the subjects, you know what I mean... history...

A But the actual structure of what they do is more confusing in technology because they do deal with so much information from different areas... they don't have to do English to do English.

G I think they're very weak at transferring things... and, erm... I think sometimes they don't think quick enough for technology.

D Oh yeah, the transferring between subjects is awful.

A But we demand an awful lot of them...

G We do.

A ... in terms of thinking and organising and so on.

S ... a very important skill, and if you've got it... /?/... an advantage... /?/... from a history lesson to an English lesson...

D Unfortunately, in some ways we are good at it, aren't we... otherwise, we wouldn't be here... so what we see as natural is going to be very very difficult for pupils, and it's the difficulty in getting that over... I mean when you see children that can't use scissors you think they're stupid...

A It's absolutely amazing...

D ... erm... you have to drop down to their level, and if that's something as simple as using scissors or a ruler or measuring or whatever it might be – erm... to actually see that they're having problems with solving problems which is an internal thing, it's going to be a more difficult thing for the teacher to spot until they've gone so far down the line that then they are frustrated, they don't want to do it any more, they switch off and you end up with this horror in the corner of the room who's not doing any work and you have to cajole them.

M I think we moddle-coddle them at this school and we're getting children from primary who can add up and write clearly and can use a ruler and can actually do good drawings and a lot of – certainly in the London schools are not getting that from the primary feeders at all – so, I mean the type of projects that we run here is very different to... erm... you know... projects in the inner-city schools... you know... I think it's quite a special case, in a way, what goes on here... and also we have very small amounts of equipment and very poor on hardware.

G ... often it comes to – they haven't got the materials to solve the problems with... they're often so poorly resourced... I think education is ridiculously poorly resourced from that point of view – actually, facilities for children come down to *me* and *my* knowledge. Because I can't really give them the time or the facilities and the equipment... go over there and spend ten minutes thinking about it and play with the bits and pieces and now see what happens, experiment with those, you know, experiment with that milk and then see what happens, you know, put a bit of heat in it and see what happens... I think that's so limited... the actually experiential aspect of problem solving... you're so – you can't find – as I say, it's now, you've got to solve the problem now... and I think, well hang on a minute, how...

A You have ten minutes!...

G ... they panic completely, yeah...

A ... to solve this problem

G ... before it goes completely wrong.

M Compare the old apprenticeships to, you know, post-sixteen... and although apprenticeships are very much a thing of the past now, I mean most people would remember them and only now are saying that they worked extremely well – and you try to pick out some factors which perhaps contributed to it's success... and no doubt they were really a rather terrifying discipline applied to the sixteen year-old – the other thing though was that the equipment was in huge abundance and readily available, and there was loads of materials and teaching was one-to-one, but, I mean the main one that comes to – because in post-sixteen groups you can have small groups and still... but there's just no gear.

Appendix K

Representative Sample Focus Group Interview Transcript - Pupils

FOCUS GROUP INTERVIEW TRANSCRIPT
'PUPILS 5' - 14/7/95

Year 9 pupil - *9S*
Year 9 pupil - *9J*
Year 8 pupil - *8S*
Year 8 pupil - *8E*
Year 7 pupil - *7N*
Year 7 pupil - *7L*

Question One **- What do you think about <u>problem solving</u> in design and technology?**

9S Erm... well, I think it's interesting how different people like... erm... find the answers in different ways and overcome problems in different ways.

9J Yeah, I think it's good like every – like that – and I think that it's good that we evaluate it as well because... like... you can look at all the problems made, you came across in doing it, and how you solved them and analyse what you did... after...

8S Erm... I think it's good because, like, it makes it your... whatever you're making... if you're trying to problem solve it then it makes it more individual to you, and it means you're doing something without having the teacher's help all the time... and do it on your own...

8E Erm... some problems you find difficult, and so you might not enjoy them as much, but some problems you might enjoy – one sort of thing that you, like... one kind of DT... sewing or something... you enjoy it, and you can find out more about it.

7N I think it's good that you have to overcome the problems because... /?/... if you don't know how to overcome the problems.

7L It's like when you – by solving your own problems you, like, learn more... because, if you get the teacher to do it for you they do it and you don't get very much... /?/...

Question Two **- Can you give me an <u>example</u> of problem solving in design and technology?**

9S We had to design a dog feeder and that was, like, interesting because lots of people came up with different ways of... to feed the dog as it were...

9J ...while she was away....

9S ... yes... and... erm... it was interesting how some people came up with, like, really simple ideas and others came out with elaborate – like, that didn't exactly work...

9J ... and the next week we had to make, like, a prototype of it and it was so funny... because, like, all the really... like, oh my... like the one I did was like really that complicated, and it just went totally wrong, whereas some of the simple ones worked quite well.

9S Yeah, the simple ones were more effective.

8S We did one where we were just told to design a board game on – erm... like you just – you could do it on anything but using only the resources that we'd got and it had some kind of link with Britain... the 'Green' aspect and stuff like that... the 'Green' environment... and it was like really weird because everybody sort of came up with... most people came up with the idea of garden parks and moving up and everything but other people came up with different ideas of things... it was good you could see all different things.

7N Well we've been making mobiles and the problem is that they haven't gone far... in far enough in the vice and half of them snapped... but to solve this problem we just turn it into another animal.

7L We done a...

7N Yes, yours snapped...

7L ... I tried three different ones before I got the one that worked... we had to, like, heat it up... we had to, like, cut holes in it so... they were quite good but apart from the snapping.

9J At the end of term sometimes – I don't know if you've ever used it, but do you remember sometimes at the end of term with *'Mr P'*, we had to do problem solving, like... they said build something that could take a certain weight or whatever, and we had to do that... that was like a one day thing...

9S ... it was a competition, wasn't it...

9J ... it was of more interest in the second year, wasn't it...

9S Yeah, it was just like an end of term sort of thing.

9J ... and they get all the DT groups together and they say there's your challenge... to each one...

8E Erm... I'm making some with the wind chimes... it was quite difficult because if you've got no wind about when you're making it you can't see if they work, and you have to get the weight right and everything.

9J ... yeah, for that we had to do it – we had to put in some kind of... using the wind instead of just having the things move in the wind...

Question Three **- Do you do problem solving in <u>any other subjects</u> in school?**

8E Not really.

Probe - Not really?

8S We did a bit in science.

9J And maths... and IT... a tiny...

Probe - And IT.

9S ... you do do them, like... but you don't think that they're problem solving, as you do in DT... but they're not as big... like in technology they might be lasting three weeks and in, say science or something, it's just one lesson...

9J DT is a double practical as well isn't it... because, with the other ones it's like if you're doing problem solving in maths it's, like, a question on a page... but you have to build the thing and if it doesn't work then it's your problem... it's not like you've got the wrong answer on the page and you just put a cross by it... you've got to make it or whatever...

Probe - That's useful... because it links to the next question...

Question Four **- Do you think there are different types of problem solving?**

A few of them Yeah...

Probe - Yeah?

9S Yeah, some are practical... and some are what you write down, and you have to kind of like develop your ideas in order to solve the problem.

8S In DT it's like you don't get as much help, I don't think as, like, in maths... because it's, like, usually linking in with a subject... say, doing division and you know it's got something to do with that... but in DT it's just... /?/...

Question Five **- How do problems get harder to solve?**

7L When something goes wrong.

Probe - When something goes wrong.

9J When it goes wrong I get really stressed over it... and I get really juddery... oh no... it's gone wrong, it's gone wrong... and something else goes wrong, like... we made this burglar alarm... and it was just so hard... the first week, I thought I would get it all done and so I made my little circuit and I was really pleased, because I'm not very good at circuits, and the next week a little bit fell off and I was, like, oh no, I'll just solder it again, and we ended up, like, every bit fell apart at some time and we were, like, soldering all these bits together and everyone was getting really stressed about it, but...

9S You start off with the problem... and you think right I know how to do this... I'll do that this week and I'll do that next week... then something goes wrong then and it's all planning again... and you're trying to think: oh God, I've got to do this, and then everyone else has finished...

9J ... it's worse if you panic...

9S ... yes, definitely...

9J ... you can't help it... you've got to try and think: right don't worry about it, and think I've only got to stick the whole thing we're doing back together again!

7L It's like when we were doing the pen box (?)... instead of breaking something and... /?/... they break even more because you weren't paying attention.

7N ... so... my problem was when mine was in the oven *'Mrs S'* bent it 'round the wrong way and it was inside out... we put it back in the oven again and bent it the right way.

8E If it gets too complicated – as well as going wrong if it gets too complicated then...

9J But sometimes if you're set something... like... you think is really easy at the end of term, then just to get a better mark you might want to make it more complicated and then you'll start... you know... sort of going wrong with something...

9S You know exactly what you want to make and you just – you can't make it and you realise as you're going wrong it's not going to work...

9J Because we all started making a leaflet and we had to think about using all different colours and everything, and then we realised we had to photocopy it... it came out and it just didn't work.

9S ... you start off and you can't think: yeah, okay then... and then it doesn't work for you, it keeps on breaking, or you can't do something with it, you just think: oh, I can't be bothered any more, and then you think: oh, I might as well try a little bit and see if it'll work, and if it doesn't work I'll start again... and: oh, never mind it's broken again...

9J Sometimes, when they set us the task, the teachers, they sound, like, easy and then they turn out to be hard, but sometimes they put about fifty starts... all this stuff on the board, and we're sitting there going what!... like we did these phone cards but the way it was described it sounded so difficult... in the end we just had to get a little bit of plastic and stick a picture on it... it sounded so difficult that everyone was going: I don't get it, I don't get it, and getting on his nerves but it was okay in the end.

Probe - So how do you think teachers make it *harder* or *easier*?

9S It depends on the way they tell you...

9J And whether they side track in the middle of it...

9S Yeah... if they just tell you the design brief straight up and no, like, tricky little bits on the end of it... yeah, alright I can do that... but, if they say: right you've got to do this, but then you've got to know all this first...

9J ... and you can't remember can you...

9S No.

9J ... especially when they were saying, like... you know the little dents inside the phone cards, and they were talking about how you change it so that it's personalised to you and how... what's it called again?... you have like a photo you print on the back... I'm going: how am I going to get a photo printed on the back, I can't even do this, and we can make it easier for the blind person, and stuff like that... it was hard, but in the end...

8S Sometimes they start to give – I mean if... they're telling you what you're supposed to be making or what the project's about, and, like, the first lesson they'll spend, like, quite a long time just telling you about the project, and by the time they've got to the end and they're telling you about the evaluation, you've forgotten what you're supposed to be doing at the beginning.

8E Yeah, they'll make you do something really complicated, like, for a blind person, and you go up to them and say: will this be okay, and they say: yeah, that's fine, but you're worrying about doing it too complicated...

8S But... we made wind chimes and our teacher was talking about how in the aerodynamics of an aeroplane's wing and stuff like this... it's a wind chime!, you just put a piece of wood in it!

8E When we were doing... erm... like, buzzers and electric circuits we – *'Mr P'* gave us, like, what we had to do... and then he started going on about how we – atoms and stuff went round the circuit and we did, like, a whole technology lesson on just that, and by the time we finished we'd forgotten what we had to do at the beginning, I think.

9J Remember that yacht... erm... that thing we did... we had to do this, like, drawing of a yacht and a wind resistance on it... but we hadn't actually done anything on it before and I took it home to my dad and I said: dad... /?/... and he was getting all his books out and I was saying: I can't do it, but in the end I just got it right, but it was really really difficult.

9S You don't think that – erm... like, you start off with the design brief and then they kind of stray from it and make you do graphical drawing or something, but then you think: well why am I doing this, it's got nothing to do with it...

9J Yeah... like that yacht...

9S ... but then you realise that it *has* actually got something to do with it, and if it hasn't actually got anything to do with that project it will help you with another one.

9J Yeah... like with the wind tunnel we were talking about wind turbines and stuff like that, and it was, like, really good because we were doing the same thing in science as well at the same time, and we were doing about wind turbines, and I was thinking: well, what's this got to do with, you know, wind chimes, and then as we were working out that, like, because it was a DT project we weren't just supposed to be making something that looked good, we were actually supposed to be actually thinking about what the wind was doing...

8S ... DT... sometimes I find a lot of the DT method becomes connected with science... because, like, when we done burglar alarms... we were doing electrical circuits at the time in physics.

***Question Six* - Do you think the teachers actually <u>teach</u> you how to solve problems in design and technology?**

2 or 3 of the group No!...

8E They let you get on with it basically... they give you a problem and tell you to get on with it.

9S They don't say: this is how to solve problems and this is what you're going to do... you have to...

9J Yeah, but if they *did* tell you about it, you wouldn't be problem solving... if they were telling you... like... to make a burglar alarm, or I want you to make a wind chime, but I want you to make the wind chime like this and I want this to be on it, then it's got nothing to do with you, it's not you doing it... so, if they're telling you how to solve the problem then there's not a lot of point in giving you the problem in the first place.

7L Sometimes they do it quite well because with the wind chime... erm... /?/... erm... make some wind chimes, we wouldn't know what to do, but she talked about the wind turbine and then we thought okay, and the problem, we *can* solve it... we had the information.

8E They do that quite a lot... they, like... they tell you about another subject which is related to the one you're doing and then you can work it out what you need to do.

9J But, usually when you're actually making it... then they'll leave you to do it right from the first lesson or something, and just to get your ideas together they usually won't help that much with it, but by the end of the lesson and you're sort of struggling to get everything done and... /?/... and they'll see a problem and they'll come along and start helping you with you with it, but sort of... because once you've actually got your idea down it's your idea anyway, so if they're helping you then it's... you know, it doesn't really matter.

9S I think it's quite hard to get – erm... because... I don't know about the others, but whenever – like... you have to work quite hard in DT to get praise, don't you, and if you get praise you think, like,: it's really good, and if they say that's good then it's, like,: oh yeah!

8E Sometimes they'll stand up and they'll say: okay, so you've done this, but will it do this... and you go: oh, right, and you think: well, can I make it do what she says...

7L You start off and then you think: right, I can do this... and you've got the problem, and you've worked it all out, and then you ask the teacher and they say: yeah, you're on the right track, and so you just continue with your idea and then, say at the end of the lesson, they say: right, next week we're developing this, because, like, everyone's got the same basic idea and everyone's developing it to take it a bit further.

8S Sometimes, you think: oh God, I've got this idea, and it's going to be really good... you know, sort of when you look at the next person it's pretty... /?/... and you think: oh, mine's better, and you go up to the teacher and they say: right, so why don't you do this to it and this to it, and you end up saying: why didn't I think of that... it's completely different now...

9Y I think it's quite good the way that... erm... you want to improve... it helps you work hard...

7N Yeah, like, if the teacher tells you what the problem is, all you're doing really is they're writing on the board and you're copying it... it's really all the teacher's work in the project.

7L ... when you start something... you always need to change it... you might draw a tree and a bird and you end up with a crab in a boat or something.

9S ... DT is quite different to other subjects because they will leave you to get on with it a lot more, whereas say... yeah, in maths... you will have a maths teacher standing at the board saying how to do something, because you're actually learning about it, but with DT a lot of it is just common sense about... you know, it's knowing about what goes and what you do where...

9J I was quite shocked when I first came to this school, actually about how much you have to do by yourself, because you're so used to having the teacher just to check every single question, like, and you're always going: is this right, is this right, but then they don't say yes to that... they say maybe...

7N It can be fun... as long as you've got the information... you know, like the rules... about turbines... it can be fun...

9J ... sometimes you think: God, are they doing anything for us, but then you realise that they're doing it for a reason... you know...

9S Going back to praise... I thought it was very good that *'Mr P'* at the end of the bag alarm project– because we didn't actually know that was part of our key stage three... and so... I mean, I said to him that: do we get a DT exam, and he goes: this is our practical, and I looked at this thing that I'd got right... I think I'll start again, and at the end of it he said... erm... oh yeah, something like: I'm very pleased because you're a very good group, and everyone was thinking that's really nice, but we'd got to make sure that we don't talk about it.

8E They do notice when you are trying... it might not work but then they notice that you're trying.

8S Yeah, that's another thing with DT... that even if it doesn't work then a lot of it is still... erm... like, valuable because, like... say in maths, and you get a problem completely wrong, and you get all the working out wrong, then you haven't really... you've gained that it's wrong, but then, like, in DT, if you've done something wrong, it sort of helps you because you know...

8E Yeah, like in science – because, in maths it can be either right or wrong... and science, you can do the same... be completely off track, but it's interesting to find out what's happening in science... because, in DT, there's no such thing as...

7L If it goes wrong you can change it slightly and carry on with what you're doing, and you can start from the beginning again, but if, say in maths, you start with something completely wrong, you can't exactly start from a new beginning... you can't start from the middle... you've got to start from the beginning.

Question Seven **- <u>Why</u> do you think you do problem solving in design and technology?**

8S I think it partly *is* design and technology, because, like, solving a problem is what you're designing... if you're sort of... erm... designing something, and it's up to you then you're going to always have problems with it, and you're always going to have to need to do it anyway.

9J I think it's a lot to do with... erm... the jobs you get later on, because we've just done in year nine 'Insight into Industry', and a lot of the stuff that we've been doing in 'Insight into Industry' is very much like DT, wasn't it... really really similar... and that's what the companies that... /?/... up to do the... /?/... it was to do with if you work in industry... there... /?/... loads of people where we are – then it's, like, connected with it.

7L I think it will help when you leave school because – I mean... /?/... if you need to make a wardrobe and you don't know how you can, like, think about it yourself, instead of just asking somebody, and it gives you that more independence to do what you want.

9J Yes... you don't have to be dependent on others.

9S It's not a case of when you leave school or go to university you'll need to know how to make a bag alarm... it's just that you've got the knowledge of how to learn how to solve this problem... a variety of different problems.

8E In maths they say, like, we're doing this trig thing, Pythagorous... and you go well: why do you need this, okay, and they say: just in case... like when you're going round the supermarket and you've got to add a bag of 500 grams of flour and 250 grams of flour... okay, so you do that in primary school, but with DT it's all manual and real, and you can...

9J ... you can't, you'll be in the middle of... /?/... sitting there and working out Pythagorous on your calculator... or something...

8E ... it's actually doing it, and you need it.

9S I also find in technology that if you like the teacher, then you'll work well for them...

8S I think most of the teachers here are alright...

7L They're okay.

9J It's like they all sort of get – the difference between not sort of telling you what to do completely... because, that was what struck me when I first came here, because... like the stuff you made... you're actually making something rather than, like – you know, at primary school, you know, you sort of make something out of cardboard boxes, okay, and it lasts alright at the time, but when you look back at it... but saying that you look back at something in DT... I've made a pencil case sort of thing where I can use it, and it's something that now I can use at... /?/... and it's stuff like that... it's something that you can actually look back on and think: yeah, I know what that's supposed to be...

Appendix L

Representative Sample Focus Group Interview Transcript - Experts

FOCUS GROUP INTERVIEW TRANSCRIPT
'EXPERTS 2' – LEA ADVISERS & INSPECTORS - 2/12/98

DW
BW
JG
AG
PH (left during Q4)
VP
JW

Question One **- What do you think about problem solving in design and technology at key stage 3 in terms of its educational merit and value?**

Probe - ... i.e., what do you think about its validity... is it worthwhile... is it successful?

VP I think it comes back... erm... we were having a conversation earlier... erm... about design and technology and 'DW' was very sort of... looking at key stage 4... and the fact that we've gone back in to sort of traditional... erm... design and technology... standards seem to be raising... becoming higher again... erm... previously with our... with a new slant to design and technology... which was exciting... with a lot of potential there but basically without training for teachers... there were problems... I think that probably is similar at key stage 3... that... unless we provide teachers with training then some types of problem solving activity will not be as good and exciting as they should be, because teachers haven't got necessarily the background to know... what they ought to be doing.

Probe - That does actually link to the second one, which is good!... so... it's just if there is any general points for...

JW ... leads to another general point... and that's what I'm assuming to be 'it', is the same 'it' as you're... in your mind...

(nothing 'given away' by the interviewer - some laughter...)

JW ... it must be a very valuable activity for children in terms of thinking about alternative ways of solving problems... did you see what they are?... comparing alternative ways of solving problems... thinking their way through those things... and also thinking of their way through them with real materials which... erm... will only do what they will do and will break if you treat them wrongly... erm... so, learning those sort of skills of decision-making and costing and choosing alternatives is actually a life skill which would apply itself to a lot of jobs, careers and life choices which children have to make... and I'm... I'll stop there because I'm not sure that I'm on the kind of target you meant... am I... am I thinking the right 'it'?

Probe - That's not for me to say... because that's part of it...

VP Do we all?... what do we think problem solving actually is?...

Probe - ... yeah... and that's part of it.

VP ... because if we've all got a different perception of it.

JG I think for me in the end it's actually testing in reality against expectations... and I think that it's unique in design and technology... you're actually testing something... and it's going to work or isn't going to work, or it's going to work well, or badly... and I think that's very different... and where I think it really scores is that in real life you will need to make some decisions... I think it's enhancing pupils' ability in making autonomous decisions... and training towards that and supporting them in their development towards that... and I think that's where it's really valuable... and that's why it's so important... but I'm biased!

(laughter...)

PH I think quite a lot of colleagues who would argue that they're involved in problem solving activities in their curriculum area... and they would agree with us that problem solving... (?)... transcending different subject areas... quite a valuable form for children to work with, I think, maybe with a few exceptions, the area of design and technology, although it varies, it gives, well most of it, it gives children an opportunity to solve problems where there is an outcome that can be measured, not in terms of success or failure, but in terms of shades of success and failure... and that's a fair reflection on life... it's a message...(?)... and being able to see that once a problem is solved... because with most problem solving a problem is not solved as such... it's just a suggested solution... is basically a life skill... and design and technology provides that opportunity... often using materials or processes etcetera, where there is a visible outcome... if it does the job...(?)... a piece of software...(?)... I think <u>that's</u> the role of the problem solving in the subject... and I think it's somewhat unique in our subject.

AG For me it is about generic skills... it's about life skills... and erm... too often for me it's not problem solving at key stage 3, it's problem creating!... where pupils don't have the opportunities to identify... opportunities for design and so it's... for me it's a fundamental skill, it's a whole-school skill, and it's something that is, from my perspective it's underdeveloped in key stage 3... so I'm not sure that you can say that what goes on is valid in key stage 3 at the moment.

VP I potentially agree with that, I think you see in primary schools at key stage 2 we see some excellent problem solving in design and technology and we see it again at key stage 4... but at key stage 3 teachers tend to quite rightly, as far as they see it, take control because they want to develop practical skills... erm... and insufficient weight is put onto AT1 (Attainment Target 1 - Designing)... (?)... and when you actually look at the level descriptors with teachers and say well actually let's look at that activity... let's look at the level descriptions... and within that activity you're not enabling the pupils to move beyond level 2 because they're not being able to make any decisions... that the decisions have been made for them... erm... and when you look at it in that... look at it that way round you can then perhaps look at the activities that are being planned for the pupils and enables decision-making and thus problem solving to actually take place.

DW Erm... what kind of problems!... and it might be kind of worthwhile looking at the two different kinds of problems... first of all, problems in designing, and secondly problems in making... and... erm... I think that generally speaking key stage 3, and of course practice varies considerably from school to school, so trying to come to any generalisations is difficult but if you could come to generalisations... and then look at the kind of problems that they face in making... are... erm... well-tackled if the teaching... if the teacher's doing a good job... so, for example, they're introduced to a particular skill... erm... a particular material or whatever... then they... they will often be... the best teaching will be encouraging them to... erm... use erm... a particular method or a particular material in order to be able to adapt that to their idea... so that they will be solving within a fairly tight framework with a defined material. Rarely, thankfully... erm do they... are they set up with a situation whereby they can select any material they may want without prior knowledge... and I think that... I think there is an issue here about an ability to solve problems based upon previous experience... and I think that when they do problem solving what they're doing all the time is to try and draw upon... is to try and adapt a previous experience to this new circumstance... so that if the children's prior experience is... erm... very limited... if we take the kind of materials area... if they're... and I think we've all said this in the past, that if their experience is limited than it is difficult for them to solve the problems... of how do you join these two bits of... how do you join these two separate materials together... plastic and wood... use a bit of PVA?... you know, or do you use a bit of Sellotape, or do you use a bit of Araldite, or do you use a glue-gun, or... now... the kind of solution to join the problems, for example, is something that they... erm... that they need to learn about in order to be able to adapt a skill. So, we've seen some 'gerry-rigged' kind of solutions in the past which have... which are indicative of pupils' lack of experience to be able to solve the problems so that the... so that the... but that generally speaking... at the moment, in the majority of schools... erm... problem solving using materials is working effectively because of the things that a couple of you earlier said... and that's about... that in key stage 3 there's a general thrust towards teaching skills and materials... it's very focused kind of like activities... a lot of focused practical tasks for instance.

The designing bit, I think, is one at issue... and it's not just an issue at key stage three... I think that children find the cognitive... erm... challenge of designing extremely difficult. I've talked to you before about the problems it creates when we look at SEN... but that I think it's true of all children... and that the... erm... we ask them to... sometimes we ask them to do things which are beyond their ability to do... not beyond their ability once they understand how to solve the problem... but sometimes, for example, at key stage 4... and I'll stray to key stage 4 because I can kind of express the example because I've kind of said what happens mostly in key stage 3... but in key stage 4 what you will get is you'll get kids that are... erm... asked to go through this bloody design process bit... you know, slavishly... for week after week after week... you've got to come up with four ideas on a piece of paper before you choose your selected one and all that sort of nonsense... whereas in fact they'd be much better sorting their problem with another material, and not graphics... and that... I think that we sometimes... sometimes... teachers don't really take the full account of that, and that there's... it's important really... it's incredible that there's teaching of design and technology that gets in the way of problem solving. Problem solving is... in my mind a fairly intuitive activity... it's something that requires a sort of... erm... trying out an idea in order to be able to test it... and that's what designing is for me... the reality of the designing is something which is a fairly orthodox approach to something... which requires pupils stepping through hoops which are not... which constrain rather than just...(?)...

BW My experience of moving around the schools has been that in fact that problem solving has in a sense withdrawn from the classroom... I've seen many many more set jobs... I see... erm... if you like the teapot stands... the teapot stand, in a sense, has almost returned... and erm, the problem-solving aspect is minimal... in fact, agreeing with *'DW'*, that in the practical sense of solving... erm, sawing a piece of wood and solving those types of problems is still going on... but that the actual designing... and solving problems in that sense is... has disappeared to a large extent... it may be the schools that I am going to of course... I mean there are good examples, I mean... in one of our schools I visit regularly... the problem solving there is excellent... but that is, in my experience, limited.

Probe - Erm... going back to a point you made earlier on... erm:

Question Two **- How do you feel about <u>teaching</u> which involves problem solving in design and technology at key stage 3?**

Probe - ... focus on the teaching...

VP I think again it's varied... and I think a number of teachers are... erm... are struggling... erm... they've got syllabi... they've got standards... erm... for which every school is required to... to reach... and there is a lot of evidence that they haven't actually got the time to really sort of... to go back and look at their key stage 3 schemes of work... work together... erm... share expertise and to actually have some quality time... some INSET time within their department or within their area where they can work with other teachers... they're just too busy with the day-to-day running of the department... and their teaching...

BW I would agree with that totally in my experience.

VP ... and the larger sizes... group sizes are getting bigger... therefore they've got... it's more difficult... the types of activities they can do when you've had sixteen or eighteen in a workshop... now they've got 24, 26... erm...

BW Or more!

VP ... or more... okay... it's constrained what they can actually do... erm... and I think very much what *'BW'* 's saying there... the teapot stand almost coming back because it's something they can manage...

BW ...it's the circumstances...

VP ... yeah... rather than... erm... enabling pupils to make a quality product that they have had their... a design input to... that they have designed it and made it... erm... I think... we're certainly seeing some dividends in Bucks where schools have looked at their schemes of work... they've identified... erm... feeder tasks... focused tasks to teach them basic skills... they've looked at the product analysis disassembly... erm... with a view to the sort of knowledge and understanding... they've set that up... then they have provided a design and make assignment in which they have actually applied... whilst they still remember it... rather than well you remember two terms ago when we did... well of course they don't have a clue... erm... but within that very recent time they're applying it... erm... and where they've actually... that seems to be paying dividends in those schools where they've actually worked along that, but as I say I think many are struggling... and money is another issue...

BW ... worrying about administration as I see it... has killed creativity... the teachers are so... I think... again... a slightly biased view but they seem to be weighed down... even the best are weighed down with... the scheme of work... it's a continual sort of development... it never actually stops... it grows and grows and grows and grows... and they don't seem to have a formula... and using a formula you've just... *'VP'* 's just expressed, does seem to be a way through that... but that means all starting again.

DW Erm... and the other thing about this is the range of content that they've got to get through... key stage three course... I absolutely agree with *'VP'*... in terms of this business of group sizes and the amount of time there is to teach, and so on and so forth... and the pressures on schools... means that really in kind of experimentation... has to some extent gone out of the window... and experimentation goes hand in hand with problem solving... and that... erm... but I think that... there is still problem solving but it's probably very limited... it's not open-ended... so...

PH ... I don't think conditions have changed that much have they... pressures have been ratcheted up... for the variety of reasons you've been saying... but still... at key stage 3 I think that is that transition from primary practice where very ambitious designing mainly because there is not a requirement to have... erm... a traditional view of how materials should be used... so some of them make adventurous solutions to problems which are readily accepted... but whether that's true of key stage 3?... I think at key stage 3 there is this... I as a teacher... a kind of teacher... still wrestle with putting together an educational experience where children take on board knowledge and understanding about the nature of materials and the way they can combine this... and... and at the same time be encouraged to produce ambitious solutions to problems using those materials... and if you divorce one from the other there's always the chance that you will either... there will be an over-emphasis on design... or children will come out with over-ambitious solutions... or there's an over-emphasis on materials and the traditional ways they are used... so they come up with expected solutions to the problems... and wrestling with that tension is what... developing a key stage 3 scheme of work is all about... and I don't think anybody's got a right answer to that... I don't think there is a right answer... I think the context will always be challenging... children will always have their personalities and strengths and teachers will have different backgrounds etcetera... erm... the danger is that all those external pressures now are... erm... making people... avoid experimenting... at resolving that tension... I think in the last twenty years that... the ambitious experiments that were tried in design and technology have rather been shown... and the lessons learnt have been lost.

BW That's what I meant by creativity... teachers just don't have the time... maybe they have got it and they won't expend it... I don't know whether...

DW It could also be this business of currently... erm... approach to designing which is almost teachers confusing designing with recording... with children spending time drawing things on bits of paper is not necessarily designing...

BW With most designing you don't do it anyway...

DW ... no...

BW ... you do a rough sketch and then...

DW ... with that problem solving bit of how to kind of resolve practical problems within the material... and we all do it as kind of makers... erm... you know... I might do very careful drawings in order to make sure that I use my materials properly, but the chances are that as I'm working with those materials my ideas change... and I wonder... you know, I want to set up something I just want to look at... and chew it over before I start making something out of that expensive piece of material... and that, you know, and the kids have got to do that on a bit of paper but without experience of, so that I think that there are constraints along those lines as well.

VP ... one or two issues with those constraints... one is that schools haven't got the capitation to spend...

DW ... yeah...

VP ... on materials to experiment with... erm... and therefore, you know, they can have a piece card or they can have a piece of wood, but they can't have both... erm... and the other thing I think is this INSET for teachers.

Probe - Erm... so linked to that...

***Question Three* - How do you think the <u>pupils</u> feel about being involved in problem solving in design and technology at key stage 3?**

BW In schools they're not inspired... they're just put off.

DW I think kids really like working with materials...

BW ... yeah... hands on...

DW ... that's the one thing that is different about design and technology.

VP And if the product that they're... the important thing is that the product that they're making is something that is going to be a quality product that they're proud to own... that it's got 'street-cred', it's 'cool', it's... and that they then use it themselves or it is something that they're proud to give to someone else... it's not something that's going to be dropped in the bin on the way out.

BW ... and that's never changed...

PH It's very rare for children to feel that even in schools where...(?)... all research at all key stages suggests that children enjoy design and technology. It's interesting isn't it when you talk to them when they're adults or mature pupils or students in retrospect they didn't really think much of the significance of it at the time... all the research suggests that children generally enjoy it... erm... even in the situations where...(?)...

VP Unless of course it is very theoretically orientated and then they don't.

JW You get feedback through your friends who have got families...

VP Also, with... erm... discussing work with pupils on inspection things that we would wince about as being good practice... children are actually enthusing and are enjoying that experience... they haven't had any other experience... they're working with materials and they are enjoying... erm... but I think where... where there is... erm... a lot of theoretical work and copying out of books... that's where they are dissatisfied and frustrated because they feel they want to be getting on with making.

JG [---] points *'DW'* made about not enjoying drawing... but if you give them the opportunity to present their ideas through their thinking style then they can actually perform quite well... erm... and for a lot of them unfortunately that means talking...

(laughter...)

JG ...but some do enjoy the 3D modelling you can actually develop quite well on that... and I've just seen a totally appropriate example... I've seen some A-level work where the design work was purely through 3D modelling... and the ideas that came out of that were fantastic... they actually really bore out the idea that people think in different ways and you've got to pick the appropriate style that supports their development.

DW And also... I mean just the graphics slant... just to keep with that point... the other thing that we sometimes do is to constrain their propensity for problem solving ability purely because of the kind of graphic style they adopt... that if you make a comparison between what happens in design and technology and what happens in art and design... the same pupil within their sketch book in art would be much more freer in their ideas than they would be in design and technology. So, I think that it is also... I keep beefing on about the orthodoxy business but I think that... (?)...

AG Well I think... they enjoy... they enjoy design and technology as an experience because it is an active experience... erm... most of... when you do pupil tracking and OFSTED stuff you realise how much they've got to sit there and just get it piled upon them... I think so... but I don't think they particularly like problem solving... and I don't think we as a group of teachers have really got to grips with the different ways that children think and like to learn... we all like to learn in different ways... some like to reflect, some like to be doing it in 3D, some like to talk... and I don't think we've addressed that issue... erm... at all... erm... in any great depth... so for me that's the sort of area that I would like to see... is how children think and how they learn in design and technology... and I think that's... that's for me important... I also... going back to the original... I'm... there's a big problem in key stage 2... erm key stage 3 which isn't there in key stage 1 and 2... in key stage 1 and 2 you've got a captive audience... you've got your class, you've got your form... when you get to key stage 3, a lot of my schools have... in a class of thirty could have 24 different schools... who will have had 24 different experiences... so the teachers are forced to adopt a sort of base-line approach, a sort of compensatory remedial approach... and that picking up *'DW'* 's point, they have to teach a certain level of basic skills for them to engage in any sort of action... erm... and consequently they don't have the opportunity to see the consequences of their actions, because teachers are... are frightened of failure, they've got the... all the sorts of pressures currently with league tables... so it's quite a complex picture, but I think that... erm... basically it's something that where we've got to look at the teaching and ways learning takes place.

Probe - Erm... again, you might feel some of these have been covered earlier to a certain extent, but...

***Question Four* - What do you think about the characteristics of problem solving?**

Probe - Do you think there are different types of problem solving, or a hierarchy, in any way?

VP That might come back to: what do you mean by it?

JW Once upon a time I read a lot of books by de Bono... and no doubt you have as part of your research... I can't remember much about it but I do think it did have some categories... erm... but I'm afraid although I was... I enjoyed reading the books very much at the time and it may have influenced my thinking... but I can't remember anything about it... so...

DW In answer to the kind of question posed... of course there are because... the kind of nature and size of problems to be solved and the kind of complexity of the... the erm... influential factors in solving the problem... so that at one level... erm... the problem to solve would be: do you go down this branch but at another point it may well be that those branches are much more complex so that they could have sub-sets to them... so that... erm... I think it... clearly there are different levels of problem solving... but that... erm... can you... I suppose the question we ought to be asking is: can you work within a kind of single model to provide for all circumstances... and I suppose that we try to do that in this kind of fictitious design-cycle thing... you know where we were saying: well, what is the problem we are kind of specifying in some sort of way... what are the alternatives to that problem, and so on and so forth... so that we've got wrapped up in the kind of general methodology of the subject area and written kind of theoretical and if you like philosophy, if you like... erm... is... is that kind of cyclical nature of how do you go about resolving design problems... erm... I mean and apply that to all sorts of circumstances which my colleagues are saying...(?)... skills and things like that... but even as well you find that... erm... maths teachers will probably say similar kinds of things, and science teachers will say similar sorts of things... they probably do have slightly... erm... they will have a different view on this as to what may well be the kind of particular way in which you go about resolving an issue.

JW For a start there are open and closed problems... in maths a problem might be a closed avenue going to one particular end... but in D&T often sort of goes towards alternative ways of solutions... for comparison...

AG And I think... I mean... you get into quite a difficult area because you begin to think about the nature of problem solving in the real world... and in the real world of manufacturing problems generally are not solved by individuals... they're solved by teams... erm... and you know, we suffer this sort of inventor-maker problem...

DW Yeah.

AG ... and that again is another problem.

DW Yeah... you're talking about... we probably don't employ... or we haven't tried in the past to a great deal of success(?)... but we don't really employ children working on group solutions to problems in the way that... erm... employ(?) in teams... but there again, it would be fictitious to do so because in the adult world teams of people usually bring...

AG Expertise.

DW ... different kinds of expertise to the problem... whereas we're faced with a problem that normally the children have got expertise and it's difficult to get them to kind of (switch?).

PH It's interesting isn't it... that it's written into the method at each key stage in the national curriculum including key stage 3... they should be able to...(?)...

(laughter...)

PH ... an interesting... I mean there must be a hierarchy... we must all consider when planning activities for children, there must be a hierarchy of problem solving. If for no other reason...(?)... able child...(?) asks you various criteria...(?)... and the gifted child says: what problem?

(laughter...)

PH ... why are you asking me this?

JG <u>There's</u> a hierarchy for a start.

AG Or more often, why is it important to me anyway?... why do I need an electronic teapot stand?

(laughter...)

BW Many of the problems we solve really are styling... I mean most of the... if you're dealing with electronics and things like that you're problem solving by picking bits, you're not really solving problems in that sense... and it's true of the whole spectrum really... the skill of the teacher is finding the level through the years a child's in school... and where the mistakes occur is that we drop the designing process on them often when they haven't the background or they're not mature enough to do the job... and if we had an overall style perhaps or system perhaps... erm... from key stage one through to key stage 3 at least... some kind of continuum where they had the tools to deal with the problem, you know...(?)... or they come along and then we dump these processes on them and when we give it to them... it's to say: right you've got to make three ideas or four ideas right, but really we haven't given them the way to get through those ideas... even if they're only styling.

Probe - Apologies for this next one, it's the OFSTED type question...

***Question Five* - How should teachers allow for <u>progression</u> and <u>differentiation</u> when teaching design and technology involving <u>problem solving</u> at key stage 3?**

VP How long have you got?!

(... general banter and laughter...)

BW If it's not written in, it won't happen...

DW ... well what are you asking *'PT'* (interviewer), are you asking <u>how</u> should it happen?, or...

Probe - How should teachers <u>allow</u> for progression and differentiation when involving problem solving...

VP They're two very different things...

JW Which one will you answer?... I'll answer the other one... I'll do differentiation, right... because interestingly with any design problem there must be differentiation by outcome, because pupils will think of different ways of making... different ways of solving the problem. There'll be differentiation by resource... well, there might be, because a teacher might give different resources and so on. There's certainly differentiation by intervention... by teacher intervention, where a teacher says to a pupil... erm... make sure you consider this, or have you thought of that way, and different sorts of interactions. What's struggling in my mind is, is it differentiation by task, which is the most common differentiation method used by teachers... and it could be!... it could be that after researching a situation, a context... but the teacher allocates tasks to pupils which are differentiated according to the ability of the pupils. Erm... that would be my thumb-nail outline of the second part... the first part about progression I think is very important... and we mentioned around the table today here... the importance of good liaison between key stage two and key stage three and how difficult it is, when... one school I was recently inspecting had 57 feeder schools... and my next question was going to be something like: do you visit your primary schools... and I didn't even ask it... you know... I thought where are they... 57 feeder schools.

VP But, okay... so they've... you've got that problem of widely different experiences... but then in key stage 3 in order to cover the range of materials, we work with a carousel... erm... and in many schools they have identified... or they're trying to identify ways of spiralling up through, rather than going round and round, so that every time... they have a new group coming to do food and textiles... the model that they are teaching is at a slightly different level, to take on board the generic skills that have come from the previous teacher, so that they can spiral through... erm...

JW ... it's very important...

VP ... and how much they're actually... the problem solving is actually coming through that as a generic... as a specific generic skill, I'm not sure!

DW I suppose it links with the ... erm... you know, with the... I'm sorry, but I'm continuing with the kind of confusing of design and problem solving... but that... erm...

Probe - That's the last question...

(laughter...)

DW ... but that it probably relates to... erm... what we've said before... I mean *'VP'* 's just been saying about the way in which they would kind of spiral up through it... and I mean I think that the... what generally happens in secondary schools is that the kids in year 7, they're very much, kind of... erm... focused task type activities with relatively little leeway... and that by year 9 in order for them to get their assessments into levels 5 and 6, you've got to do things that are a little bit more open-ended and therefore present themselves with more difficult problems. And the reality of it though is that despite the fact that if you take things like... erm... I mean, the classic example of... erm... to investigate... erm... existing solutions to a problem, etcetera. Now, the research side of it... erm... and the bits about... erm... you know... think about the needs of others and all that kind of stuff gets reduced down to... erm... looking through the Argos catalogue... and erm... and it allows somebody to kind of tick it off the list without it really being handled in-depth or kind of understanding whatsoever... so that... erm... and that... what will happen as it then becomes more kind of useful is that we will have electronic versions of the Argos catalogue... so...

BW ... we've got CD Roms now...

DW ... so that the kind of idea of thinking about others is... erm... is not always fully explored... and that... erm... also there's post-hoc designing as well, you know... like... erm... your planning for making is done after you have finished... and so there's quite a bit of that going on as well. But generally speaking I think that the way in which the secondary schools will structure it is that with year seven it is much more closed and by year 9 that the kind of... the problems are a bit more open.

JG I think actually it also happens that in the early years you'll actually find that things are very aesthetically challenged so they might only be asked just to shape something or to colour something in, which I think is rather sad... erm... but also it's very subjective... it's very much a reaction to what I want... whereas as you go further up you're expecting like generic solutions or individual specific needs solutions... and the needs and interests are then going to be placed very much in a context which they're going to need to resolve.... and there'll be conflicting interests as you go further up... so I think that difficulty of problem is increased complexity and conflict and they've got to resolve those... and of course, more possible outcomes... but early on, I mean, I think is very much very narrowed and erm... and the actual problem solving is perhaps very limited as such, and it's not so real either.

AG I come back to *'JW'* 's point... I'd like to visit these schools because I don't think I've ever seen differentiation and problem solving by task... I've seen it by outcome... but I just really... it's just to note that really. Erm... it's the whole issue of... erm... matching tasks... erm... how can we say that the kids have solved a mechanical problem if they've all designed a cam toy, admittedly with different things on the top of it, but they've all used the same mechanism... and they can't describe the mechanical systems that they've used... they can't even articulate the input, the process, and the output... they don't realise that the cam is a processing part and all the rest of it, so... erm...

BW The reality is that if it's not planned in to start with then surely it comes down to the process of planning and that's where everyone has been focusing on in their schemes of work... but they've never really developed that [--] you can't know it, but if you can't see it's happened... or you've got it... if you haven't got it as input to start with and with many of the schemes of work, and I've run courses for a number of schools where they've not... And in fact I heard yesterday about one for... erm... Brent where I had helped them and it suited the HMI that went in last week and they were very pleased with it... had a glowing report... but none of what you're asking... the questions you were asking there would be addressed by the teacher... I don't think they really understood it quite frankly... that question wouldn't have been relevant.

Probe - The next question is...

Question Six **- Do you feel that the teachers actually <u>teach</u> problem solving?**

? Sometimes.

DW I think we've got to bear in mind the kind of... I think that the levels that we've talked about... that... erm... 'yes' is the short answer, they do... but they might not do all levels of problem solving... where it is dependent on the kind of... the... the nature of the task that's going on... you know... I do think that with even the relatively closed problems... they do provide opportunities for problem solving... it's only where you've got literally the kind of drawing where the children have got to make it all the same, that you get the situation where you've... and you could argue that even in those situations there's an element where there's a bit of problem solving going on... it's probably not that the teachers are doing it... (?)... although the teachers aren't encouraging it there is some going on... but they are getting involved in cases where they do provide an opportunity to solve some kind of problem, but that it's a question of the level at which that problem they've got to solve might be... so it might be: do you make that round or do we make it square; but at another level it might be: do we use this material or do we use that material; or at another... admittedly a higher level is who... you know, what is the problem that you... you know, can you find a problem to resolve... so that I think that there are different levels and yes, I think that teachers do teach it because I think that most good design and technology teachers encourage questioning... they kind of... they're not... they won't... what they will do is they will provide children with a safety net so that... so that they... erm... don't fail, but that where they know the children are given a question rather than a solution, they'll do so... and good design and technology teachers will dot that all the time... so they'll point them in the direction but the children will solve the problems for themselves, so that the children get a little more confidence in dealing with it... but that... erm... but that they... erm... they don't... that in key stage 3 that's rarely at a very high level... merely because of all the things that we've talked about before, and it's largely to do with group size, the amount of materials they've got available, and so on and so on... so it's largely a resource problem... because of the... (?)... children that go through key stage 3.

JW I don't think you ever see... at least I don't see teaching <u>about</u> problem solving... I don't hear teachers saying to pupils: well there are problems which are open-ended and problems which are closed-ended for a variety of situations... I don't hear that kind of lesson ever. Erm... there are lessons, like *'DW'* was describing where the children go through the <u>process</u> of solving a problem, but they don't have procedures for solving problems taught to them. The nearest they get to that is any teaching they get about designing... where teachers will be saying, you know, I want you to think of three ways of solving this problem... and then compare them, alright a specification for what they're trying to do... erm... that's the nearest you'll get to it in D&T... in some of the other subjects you might get it more...

JG I think sometimes with that encouragement with the three different... it could be four different solutions, is to try and get them to start thinking of different... and it's often that that's forgotten... and erm... yes, I think you're right, I don't think there is a lot of support in how you go about finding out what's different... but if you've got that context then you can start trying to get them to explore different aspects of that context... if it's mechanical you might say well what sort of movement do you want and you might start with movement charts... erm... and things like that... and the old things used to be these sculptures and you'd often get people doing a variety of different techniques... one of which is just to scribble things and pick out some shapes... and that being the first starting point and maybe they could geometric them... so there could be different ways of looking at the situation and coming at the solutions, but I don't think that's done a lot now, I think that's... I think people have actually seen... erm... the stock answers like the cam solutions and they find that people are getting good marks for those... and it looks very nice, and people getting pats on the backs for them, so lots of people are going down that line.

Probe - There's two questions left... erm... next one...

***Question Seven* - Do the teachers have *access to any information* about teaching involving problem solving?**

BW 'No' is the short answer to this question.

DW ... undigestible... well the thing is they do or they don't... I mean, in a way with my...(?)... hat on...(?)... it's kind of sort of the pressure on time. And also that what they're doing is they're concentrating on the things that, as *'JG'* said, they're concentrating on the things that they get the good marks for... they've got this kind of pressure on schools, it's about league tables and performance...(?)... but that... but that they'll go... they'll go down that route rather than looking for something which is more kind of academically challenging...

BW They want answers... they want off-the-shelf solutions really... you know, if it's a good idea it goes round like a virus... it just does... it spreads... I mean, okay, they'll change this bit and change that bit and tweak that bit, but it's a virus, it spreads...(?)... plenty of material and data... I mean they're there anytime.

JW Well, who ever said the cam toy was good idea, it's certainly gone round like a virus...

(laughter...)

JW ... everywhere somebody is... some of it is absolute rubbish isn't it... really stupid stuff... and they're doing it in year 10 and 11.

AG I don't know, I think a rabbit popping out of a hole and a guy spinning around with a gun in his hand's quite good if, you know... every time it's good, you know, it's great... I've seen lots of gunmen doing this.

JW Yeah, in year 6 it's good...

AG ... absolutely...

JW ... but not year 11.

Probe - The final one... erm... it comes back again to some points raised earlier... erm, particularly what you mentioned before...erm...

***Question Eight* - What do you think about the relationship between '<u>problem solving</u>', '<u>creativity</u>' and '<u>designing</u>' in design and technology?**

DW Well, as I say, I keep beefing on about it... but it's a question of... about designing... there are a lot of teachers who confuse... erm... who confuse designing with recording... and then I think that at the best... I mean you've got to think about a spectrum here, with teachers as much as pupils... but that at one end of the spectrum you've got the teachers who are good... who have a good understanding of design... and they can employ design thinking in a way that is quite exciting for children... it gets them involved in... erm...that problem solving is part of it... but broader than that... so, design's a... you know, a range of things which would include aesthetics, which would kind of include kind of statistical data from accountability of products or whatever, you know... and that they come to a solution... but that for probably the majority of teachers of D&T, they're not really designers themselves... and that... erm... and so probably what they'd... and that's the reason why many many schools fall into this kind of orthodoxy of the kind of design solutions bits... you know, the kind of the same steps... and you can't blame them because of that, because that's what the syllabus expects as well.

BW At key stage 3 there isn't much time for all these things... with large numbers, up to thirty-odd in classes!... and to be employing all those things... lovely with a small group and a technician on hand... most teachers I'm sure could achieve good creative problem solving with a lovely design approach, but under current conditions really...

DW I think the question really is about 'is there a difference', yes there is.

JW Yes, there is...

DW Yes, there is.

JW ... erm... there is a Russian Doll thing too isn't there... erm... designing must include creativity and problem solving, but not necessarily the other way round... is that right?...

(laughter...)

JW ... I think.

JG Problem solving can be lots of very small steps... and creativity you can have that leap... and you can't see that leap... that link necessarily... it's not always there is it... you've suddenly gone from there to there and that imaginative jump can't be traced back through whatever was there before. And designing can actually be very plodding can't it, it can actually be very methodical and quite dull and at the end you can have a possibly predictable solution, but you've gone through lots of... erm... what would appear to be very linear sensible stages that we're forced into... as *'DW'* keeps saying... erm... and so lots of problems can be...

JW Hang on, creativity can be done with a violin!

JG ... erm... absolutely... but if you have that creativity...

JW ... but you couldn't design with a violin... so... could you?...

(laughter...)

JW ... no... not in the same way, you couldn't... so there's another difference there somewhere...

JG ... mmm... but when you have that creative leap...

JW ... you can't problem solve with a violin either... so there are sets of things which work in one extreme, but not the other... is that right?

DW No, I think that probably musicians would disagree you... erm... I think that you probably can get musicians that are probably just problem solvers that don't have any creativity... that they can put together...

JG ... mmm... they just go through it...

DW ... that they can put together a few kind of notes...

JW ... yeah, okay...

DW ... and it sounds like a kind dirge or it sounds like a jig... erm... and in that sense all that they're doing is they're applying their kind of previous understanding of bits of it... and they're just...

JW ... they're putting components together...

DW ... putting components together... they've solved a problem that somebody's asked them to do...

JG ... and that's a plodding approach...

DW ... can you do a little kind musical jig for me for this kind of little advert I'm doing... so... whereas somebody could ask the same question and somebody could come up with a really creative input and kind of solution to it... so I think that probably...

JW ... mmm... if you look at the design of the new German... erm... parliament building... what do they call it... erm... there's a lot of existing components and ideas like heat exchangers and things that have been brought into that... and yet it's supposed to be a very innovative thing... I mean is all designing like that... putting in some existing ideas.

DW I suppose the kind of argument is how many angels are there on a pin-head... I mean it's... it's the kind of words that you decide to use, and whether or not we decide that you're going to use terminology to kind of define what problem solving is, what creativity is, and what designing is... and in a way your motivation is to kind of talking about some sort of... erm... kind of meaning of the word...

JW Creativity means in producing something new... it's a creation... so that is one activity... creating something new... designing might be producing something new, or it might be using existing products or components.

JG Good designing <u>may</u> include creativity.

JW Yes... it probably <u>should</u>, but won't necessarily.